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SAUGET AREA 2,
SAUGET, ILLINOIS

SUPPLEMENTAL INVESTIGATION – PHASE 2 & 3 WORK PLAN

Prepared for

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TABLE OF CONTENTS

List of Tables

List of Figures

TABLE OF CONTENTS

List of Attachments

Glossary of Abbreviations and Acronyms

ABRTF	American Bottoms Regional Wastewater Treatment Facility
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirements
ATSDR	Agency for Toxic Substances and Disease Registry
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CGM	Combustible Gas Meter
COC	Constituent(s) of Concern
CPT	Cone Penetrometer Test
DHU	Deep Hydrogeologic Unit
DO	Dissolved Oxygen
DOT	Department of Transportation
ERRS	Emergency and Rapid Response Services
FSP	Field Sampling Plan
GC	Gas Chromatograph
GC/MS	Gas Chromatography Coupled with Mass Spectrometry
GMCS	Groundwater Migration Control System
GPS	Global Positioning System
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
HI	Hazard Index
IDW	Investigative-Derived Waste
IEPA	Illinois Environmental Protection Agency
LCS	Laboratory Control Sample
LNAPL	Light Non-aqueous Phase Liquid
MGD	Millions Gallons per Day
MHU	Medium Hydrogeologic Unit
MLE	Most Likely Exposure
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MSL	Mean Sea Level
NAPL	Non-Aqueous Phase Liquid
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
ORP	Oxygen Reduction Potential
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PCB	Polychlorinated Biphenyl
PID	Photoionization Detector
PM2.5	Particulate Matter 2.5µm
POTW	Publicly Owned Treatment Works
PPE	Personal Protective Equipment
ppb	parts per billion
ppm	parts per million
PRP	Potentially Responsible Party
PUF	Polyurethane Foam

PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RAGS	Risk Assessment Guidance for Superfund
RAM	Real-time Aerosol Monitor
RAO	Remedial Action Objective
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SA2	Sauget Area 2
SA2SG	Sauget Area 2 Sites Group
SDG	sample delivery group
SHU	Shallow Hydrogeologic Unit
SSP	Support Sampling Plan
SVE	Soil Vapor Extraction
SVOC	Semi-volatile Organic Compounds
TAT	Technical Assistance Team
TCLP	Toxicity Characteristic Leaching Procedure
TOC	Top of Casing
UCL	Upper Confidence Limit
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency
VOC	Volatile Organic Compound

Phase 1 of a Supplemental Investigation was conducted between June and August 2005 to fill identified data gaps in the Sauget Area 2 Remedial Investigation (RI). Following the completion of Phase 1 of the Supplemental Investigation, two meetings were conducted with the Sauget Area 2 Sites Group (SA2SG), United Stated Environmental Protection Agency (USEPA), USEPA's oversight contractor CH2MHill and Illinois Environmental Protection Agency (IEPA). During the initial meeting on September 15, 2005, a phased process was developed to finalize the Remedial Investigation/Feasibility Study (RI/FS) Report. These phases included:

- Phase 1 – Supplemental Field Investigation
- Phase 2 – Installation of monitoring well clusters designed to address data gaps
- Phase 3 – Non-aqueous Phase Liquid (NAPL) Investigation
- Phase 4 – Completion of a regional fate and transport groundwater model (will be conducted following the completion of Phase 2 and 3 activities).

The second working meeting was conducted on December 14 and 15, 2005 in which the scope of work for implementation of Phase 2 and 3 was further defined. The scope of work that was discussed during that meeting by the SA2SG, USEPA, USEPA's oversight contractor CH2MHill, and IEPA is reflected in this Work Plan.

The objective of Phase 2 of the Supplemental Investigation is to fill the remaining data gaps associated with the groundwater impact observed at the Sauget Area 2 sites. As previously stated, the SA2SG and the USEPA have agreed upon a scope of work to fill these data gaps, the findings of which will be included in a revision of the RI/FS report. This scope of work includes the installation, development, and sampling of well clusters at ten locations, the advancement of a soil boring at one location, and the completion of three groundwater profile locations. These individual tasks are described below.

2.1 MONITORING WELL CLUSTERS

A total of ten groundwater monitoring well clusters will be installed to identify and monitor the edges of the various groundwater plumes originating from within and upgradient of the Sauget Area 2 sites. These ten monitoring well clusters will contain three wells; one well screened in each of the three hydrogeologic zones identified on-site, which have been described as the shallow hydrogeologic unit (SHU), the medium hydrogeologic unit (MHU), and the deep hydrogeologic unit (DHU). Historically, groundwater was not observed in the SHU in portions of Site Q Central and some well clusters will be completed with existing monitoring wells. Therefore, it will not be necessary to install three wells at each location during Phase 2. A summary of the locations in which only one or two monitoring wells will be installed during Phase 2, is provided below.

- SA2-MW-7: Shallow aquifer well SA-Q-6 already exists in the SHU, therefore wells will only be installed in the MHU and DHU.
- SA2-MW-8: Water was not present in the SHU and shallow aquifer well SA-Q-8 already exists in the MHU, therefore, a well will only be installed in the DHU.
- SA2-MW-9: Shallow aquifer well SA-Q-9 already exists in the SHU, therefore wells will only be installed in the MHU and DHU.

2.1.1 Monitoring Well Installation

During the course of installing the well clusters described above, 26 groundwater monitoring wells will be installed using sonic drilling technology. These monitoring well locations are presented on Figures 1 through 3 and summarized on Table 1.

The soil borings for each new monitoring well will be completed by continuously advancing a 4-inch core barrel and 6-inch override casing through the subsurface soils and waste materials (if present) to the desired installation depth. The 6-inch override casing will be temporarily left at the base of the boring to serve as an isolation casing, preventing vertical migration of contaminants within the alluvial aquifer through the borehole. A seal will be formed by the sonic resonation of the 6-inch override casing as it is advanced by energizing the waste and soil material surrounding the casing and when the resonation stops, the energized waste and soil material seal back around the casing providing a tight seal and preventing the migration of groundwater downward along the casing wall.

Continuous soil samples will be collected from the 4-inch core barrel. Soil samples from each boring will be visually evaluated for evidence of impact and screened in the field using a photoionization detector (PID). The subsurface stratigraphy will be logged during drilling operations by a qualified field scientist in accordance with the Unified Soil Classification System (USCS) and standards outlined in Attachment 2. The field scientist will note soil attributes such as color, particle size, consistency, moisture content, structure, plasticity, odor (if obvious) and organic content (if visible). Information pertaining to the subsurface soil and waste materials and drilling conditions will be recorded in the field on a standard field boring log form.

Upon completion of each boring, a monitoring well will be installed. If the total depth of the boring extends beyond the desired monitoring well installation depth, the borehole will be backfilled with hydrated bentonite chips to a depth of 0.5 to 1 foot beneath the base of the well screen. This bentonite seal will prevent the downward migration of groundwater or leachate. A 0.5 to 1-foot thick silica filter sand buffer layer will be placed above the bentonite backfill and beneath the well base to prevent the bentonite backfill from expanding into the well screen after hydration.

Monitoring wells will be constructed of a stainless steel riser pipe and ten feet of well screen with a 0.010-inch slot size. A sand filter pack consisting of 20/40 sieve size silica sand will be installed from the bottom of the well to a distance of 2 feet above the top of the screen and a 3-foot thick bentonite seal will be placed above the sand pack. The remaining annular space above the bentonite seal will be filled with bentonite/cement grout to approximately 3 feet bgs. All well construction materials will be placed through the 6-inch override casing.

The override casing will be extracted from the borehole at an equivalent rate to that of the filter sand and bentonite being introduced into the annular space of the well. In addition, the override casing will be resonated during its removal to assist in the formation of an effective seal between the bentonite and surrounding subsurface materials. The upper 1.5 to 3 feet of annular space will be filled with concrete. Any variations in the height of the sand pack above the well-screen, thickness of the bentonite chip seal or grout layer, or depth of concrete will be a result of variations in the total depth of each shallow aquifer monitoring well. Wellheads will be either finished as above ground completions or flush-mount completions, depending on the wells location and potential interference to vehicular traffic. Keyed-alike locks will be placed on each well for security purposes. The monitoring well installation SOP is presented in Attachment 4.

Excess soil cuttings and liners will be placed in Department of Transportation (DOT) approved 55-gallon drums that are labeled, sealed, and staged on-site. Sampling equipment (core barrel, override casing, drill rig) will be decontaminated between borings using a steam pressure washer.

Survey

To ensure that all survey information for these wells uses a consistent datum (the horizontal datum is Illinois West State Plane 1983, NAD 1983 and the vertical datum is NAVD 88), an Illinois licensed surveyor will establish the horizontal and vertical locations for the monitoring wells. Survey data will be presented with respect to site benchmarks.

2.1.2 Monitoring Well Development

After groundwater levels are measured, the newly installed groundwater monitoring wells will be developed. The objective of groundwater monitoring well development will be to remove fines from the well screen and filter pack so that representative groundwater samples can be collected. The Standard Operating Procedure (SOP) for monitoring well development is presented in Attachment 5.

Prior to monitoring well development, the well head and surrounding vicinity will be scanned with a PID to verify that the well development activities can be conducted safety. In addition, the well head and surrounding area will be scanned periodically during development (approximately once per well volume) to verify that the atmospheric conditions have not changed and the work can continue safely. The action levels are provided in the site-specific Health and Safety Plan (HSP). Once it is determined that work can proceed safely, development of the monitoring wells will be accomplished using an airlift system. The water inlet will be placed approximately 5 feet above the bottom of the well (near the middle of the well screen). The well will be surged, using the injected air (not a surge block), across the screened interval during pumping to agitate the water and suspend the sediments in the well so that they can be removed. Water will be pumped from the well and discharged directly into DOT approved 55-gallon drums, which will be labeled with the well identification number, site location, date and contents. Development will continue until an amount of water equal to one times the amount of water lost to the formation during drilling (as estimated and recorded at the time of drilling) and a minimum of five well volumes of water have been removed from the well and the pH, conductivity, and temperature have stabilized. Readings will be collected after each well volume of water has been removed and considered stable when two consecutive measurements are within the following criteria:

- ± 0.2 units for pH
- ± 10 percent for specific conductivity
- ± 1°C for temperature.

Monitoring wells that purge dry during development will be purged dry three times. The water will be allowed to recharge to static conditions between each cycle of purging. If the well does not recharge to static conditions within 24 hours the well will be considered dry and development complete. Information relating to the development of each monitoring well will be documented on well development forms.

2.1.3 Monitoring Well Sampling

Groundwater samples will be collected from each of the newly installed groundwater monitoring wells. A summary list of the newly installed groundwater monitoring wells, their IDs, and the parameters to be analyzed for is presented in Table 1. This information will be used to update and refine the regional groundwater model.

Groundwater Elevations

Prior to sampling, the water level and total depth of each monitoring well will be measured from the top of casing (TOC) to the nearest 1/100th of a foot using an electronic interface probe. These measurements will be recorded and used later to determine well volume and development needs.

Purging

Following completion of groundwater gauging, each monitoring well will be purged prior to sampling. The monitoring wells will be purged using low-flow methodologies including a flow-through cell and a conventional groundwater pump, suitable for low flow applications (i.e., bladder pump [or equivalent]). When purging begins, the pump flow rate will be started at approximately 100mL/min or the lowest flow rate possible. Water level measurements and flow rate measurements will be taken every 2 minutes until they indicate that significant drawdown within the well is not occurring. Measurements will be scaled back to every 5 minutes when drawdown reaches equilibrium. Ideally, drawdown will be limited to 25% of the distance between the top of the screen and the pump intake. If significant drawdown occurs, the well will be pumped dry. After being pumped dry, the well will be periodically gauged until the water level has recharged to approximately 90% of the original, static level prior to sampling. If in 24 hours the well has not reached 90% static recovery, the well will be sampled.

Each monitoring well will be purged until pH, specific conductance, and temperature readings stabilize over a minimum of three successive flow-through cell volumes or one hour has elapsed and the data are indicative of groundwater from the formation, whichever occurs first. The field parameters will be measured and recorded during purging. The allowable ranges for the criteria used to determine stabilization is provided below:

- $\pm$ 0.2 units for pH
- $\pm$ 3% for specific conductance
- $\pm$ 0.2^{o} C for temperature.

Along with pH, conductivity, and temperature readings, field parameters recorded using a flow-through cell during purging will include turbidity, DO and ORP.

Water will be discharged into a graduated pail and then transferred to DOT approved 55-gallon drums, which will be labeled with the well identification number, site location, date and contents.

Groundwater Sampling

Groundwater samples will be collected at a flow rate no greater than 0.5 L/min using the same pump used for purging. Samples will be discharged directly into laboratory supplied sample containers. Each sample container will be labeled with a sample identification number, site name, sampler's initials, date and time of sample collection, preservative, and the parameters to be analyzed. After sample collection, each label will be sealed with clear polyethylene tape and the samples will be logged on a chain-of-custody form, packaged to prevent damage during shipment, and cooled with ice to 4°C. If NAPL is present, efforts will be made to collect water above or below the NAPL layer.

The groundwater samples along with the corresponding chain-of-custody form will be shipped via an overnight delivery service to a laboratory for analysis of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), herbicides, metals, and ammonia and several geochemical parameters, which include methane, nitrate, carbon dioxide, alkalinity, sulfate, manganese, chloride, ethane, ethane, and total organic carbon (TOC). In addition, the samples from the SA2-MW-4 well cluster adjacent to Site O will be analyzed for dioxins, pesticides, and PCBs. Due to the short hold time, ferrous iron (a geochemical parameter) will be analyzed in the field with a spectrophotometer. A summary of groundwater analytical parameters is presented in Table 1.

Photographic documentation of the installation, development, and sampling of the groundwater monitoring wells will be collected. The low flow groundwater sampling SOP is presented in Attachment 7.

If NAPL is observed in any of the groundwater monitoring wells sampled during this investigation, a reasonable effort will be made to collect a sample of the NAPL, consistent with previous investigations.

2.2 GROUNDWATER PROFILING

Groundwater profiling will be conducted to further define the northern edge of the groundwater impact observed both upgradient and downgradient of Site P. Groundwater profiling will be conducted at three locations adjacent to Site P and will consist of collecting groundwater samples from multiple depths throughout the alluvial aquifer. The sampling locations are presented on Figures 4 and are summarized below:

- 1 location upgradient of in Site P
- 1 location downgradient of Site P
- 1 location north (side gradient) of Site P.

Groundwater samples will be collected at 20 foot increments from the top of the water table to the bottom of the aquifer using the hydraulic push system of a Geoprobe® to advance a 4-foot stainless steel slotted sampler (slot size of 0.002 inches) to the desired sample depth. Discrete groundwater samples will be collected using modified low flow methodologies. Polyethylene tubing will be placed down the inside of the probe rods to purge and retrieve a sample of the groundwater with a groundwater pump suitable for low flow applications, (i.e., bladder pump or equivalent). If water cannot be collected with a conventional pump, (e.g., due to physical size limitations of the equipment and probe rods), polyethylene tubing with a check ball may be used. Sampling equipment used between each discrete sampling will be either new or decontaminated. If NAPL is present, efforts will be made to collect water above or below the NAPL.

When purging first begins, the pump flow rate will be started at approximately 100 mL/min or the lowest flow rate possible. Water level and flow rate measurements will be taken every 2 minutes until they indicate that significant drawdown within the drill rods is not occurring. This will ensure that groundwater is entering through the screen and not from inside the drill rods. Measurements will be scaled back to every 5 minutes when drawdown reaches equilibrium. Ideally, drawdown will be limited to 25% of the distance between the top of the screen and the pump intake. If significant drawdown occurs the drill rods will be pumped dry. After being pumped dry, the rods will be periodically gauged until the water level has recharged to approximately the original, static level prior to sampling. If drawdown is not occurring, the pumping rate may be increased until equilibrium is reached.

Groundwater samples will be collected after the pH, specific conductivity and temperature have stabilized over three consecutive flow-through cell volumes or one hour has elapsed and the data are indicative of groundwater from the formation, whichever occurs first. The field parameters will be measured and recorded during purging. The allowable ranges for the criteria used to determine stabilization is provided below:

- $\pm$ 0.2 units for pH
- $\pm$ 3% for specific conductance
- $\pm$ 0.2^{o} C for temperature.

Along with pH, conductivity, and temperature readings, field parameters recorded using a flow-through cell during purging will include turbidity, dissolved oxygen (DO) and oxidation reduction potential (ORP).

After sample collection is complete at the desired depth, the sampler will be advanced to the next desired sample depth by connecting clean sections of push rods to the Geoprobe®. This process will be continued until all samples are collected. New polyethylene tubing will be used for each sample depth. Each alluvial aquifer boring will be sampled from the water table to the bottom of the aquifer.

Samples will be collected using the same pump as used for purging, but with a flow rate of no more than 0.5 L/min. The samples will be collected by allowing the groundwater to flow directly into the laboratory supplied sample containers. Each container will be labeled with a sample identification number, site name, sampler's initials, date and time of sample collection, preservative, and the parameters to be analyzed. After sample collection, each label will be sealed with clear polyethylene tape and the samples will be logged on a chain-of-custody form, packaged to prevent damage during shipment, and cooled with ice to 4°C.

The groundwater samples, along with the corresponding chain-of-custody form, will be shipped via an overnight delivery service to the laboratory for analysis of VOCs, SVOCs, herbicides, metals, and ammonia. A summary of groundwater analytical parameters is presented in Table 2.

Upon completion of each alluvial aquifer boring, each Geoprobe® hole will be sealed with grout from the bottom up using the Geoprobe® rods as a tremie pipe and the surface will be returned to its original condition. Purge water will be placed in DOT approved 55-gallon drums that are labeled, sealed, and staged on-site. The sampling equipment (Geoprobe® rods) will be decontaminated between borings using a steam pressure washer.

Photographic documentation of the alluvial aquifer sampling will be collected. The groundwater profiling SOP can be found in Attachment 17. The low flow groundwater sampling SOP is presented in Attachment 7.

If NAPL is observed in any of the groundwater profile borings, a reasonable effort will be made to collect a sample of the NAPL, consistent with previous investigations.

2.3 SOIL BORING

One soil boring will be advanced to bedrock in the southern portion of Site Q Central using sonic drilling technology as described above in Section 2.1. The proposed location of this soil boring is presented on Figure 5. One surface (0-0.5’) and subsurface (0.5’-6’) soil sample will be collected for laboratory analysis from this boring. One waste sample will be collected if gross contamination (as defined in Attachment 21) is present. Continuous soil samples will be collected from the 4-inch core barrel. Soil samples will be visually evaluated for evidence of impact and screened in the field using a PID. A discrete surface and subsurface soil sample will be collected from the interval exhibiting the highest PID reading. The subsurface stratigraphy will be logged during drilling operations by a qualified field scientist in accordance with the USCS and standards outlined in Attachment 2. The field scientist will note soil attributes such as color, particle size, consistency, moisture content, structure, plasticity, odor (if obvious) and organic content (if visible). Information pertaining to the subsurface soil and waste materials and drilling conditions will be recorded in the field on a standard field boring log form.

The samples will be transferred to laboratory-supplied containers. VOC samples will be collected using a 5-gram EnCore™ sampler (or equivalent) as described in Attachment 16. Each sample container will be labeled with a sample identification number, site name, sampler's initials, date and time of sample collection, preservative, and the parameters to be analyzed. After sample collection, each label will be sealed with clear polyethylene tape and the samples will be logged on a chain-of-custody form, packaged to prevent damage during shipment, and cooled with ice to 4°C.

The samples, along with the corresponding chain-of-custody form, will be shipped via an overnight delivery service to the laboratory for analysis of VOCs, SVOCs, herbicides, metals, and ammonia.

Upon completion, the soil borings will be sealed with grout from the bottom up using the 6-inch sonic over-ride casing as a tremie pipe and the surface will be returned to its original condition. The soil cuttings will be drummed and the drums will be labeled and stored for future disposal. The location of this soil boring will be surveyed using a GPS unit.

A NAPL Investigation (Phase 3) will be conducted to identify the nature and extent of both residual NAPL remaining in the interstitial spaces of the soil and pooled NAPL sitting on the groundwater surface (light non-aqueous phase liquids (LNAPL)) or on the bedrock surface (dense non-aqueous phase liquids (DNAPL)). The NAPL Investigation will be focused on two areas based on previous investigation results:

1. Leach-P-1
2. Sonic-5.

The investigation will include the collection of one NAPL sample from location Leach-P-1 for laboratory analysis as well as the advancement of soil borings and installation of monitoring wells around Sonic-5. Soil borings and monitoring wells will not be advanced or installed adjacent to Leach-P-1 because other sampling locations have provided a maximum lateral extent of the NAPL observed. These locations are:

- SA-P-1 – North
- AT-P-2 – South
- TT-P-2 – N1 and N2 – East
- Ravine – West.

A sample will not be collected from Sonic-5 because a sample of the NAPL was collected from the geotechnical boring in May 2002, when the NAPL was first identified. This sample was sent for chemical analysis to Severn Trent Laboratories. The laboratory analytical sheets are provided in Attachment 22. The physical and chemical characteristics of any additional NAPL observed in that general area will be assumed to be consistent with the existing sample. A description of the specific activities for the NAPL Investigation is provided below.

3.1 SOIL BORINGS

Sonic drilling technology (as described in Section 2.1) will be used to advance as many as eight soil borings to bedrock. Initially, three soil borings will be advanced approximately 50 feet south of the barrier wall in a general east/west orientation adjacent to location Sonic-5. The presence of NAPL will be evaluated based upon both visual evidence and the results of hydrophobic testing (Sudan IV vial test). If NAPL is observed in these three borings, then the corresponding step-out borings will be completed. A maximum of five step-out borings will be completed as shown on Figure 6. Following completion of the borings, the USEPA and SA2SG will discuss the placement of the three monitoring wells and if additional borings are required. If any of the soil borings need to be moved due to utilities, they will be generally moved in the following directions:

- A locations move east
- B locations move south
- C locations move west.

For these soil borings, continuous soil sampling will be conducted from the ground surface to approximately 5 feet into the bedrock, with a total depth of approximately 140 feet bgs. Continuous soil samples will be collected from the 4-inch core barrel. Soil samples from each boring will be visually evaluated for evidence of NAPL and screened in the field using a PID every 2 feet. In addition, the soil cores will be screened for the presence of NAPL using vial test kits containing Sudan IV dye. To evaluate a soil core for NAPL using the vial test kit, measured volumes of soil and water are added to a test vial and agitated. Within the vial, a sugar cube that contains a premeasured mass of Sudan IV dye dissolves during the agitation and stains any NAPL red. Another dye within the sugar cube stains the water green, which makes the red dye more visible. Agitation of the sample will continue until the sugar cube is entirely dissolved, and the jar will then be inspected for evidence of NAPL. If there is no indication of NAPL, the sample will be agitated again, allowed to sit for a minimum of 5 minutes, and reinspected. If no areas of red coloration develop within the jar over at least a 5-minute period, the test will be considered negative for NAPL. A minimum of one Sudan IV vial test will be completed for each ten foot soil core, however, if there are several areas of potential NAPL identified, multiple tests will be performed. The Sudan IV field screening SOP can be found in Attachment 19.

Soil samples for laboratory analysis will also be collected from the initial three borings located approximately 50-feet south of the barrier wall. One undisturbed soil sample, without apparent NAPL, will be collected from each hydrogeologic unit (SHU, MHU, DHU) in each of the three initial borings and will be submitted for geotechnical testing, which includes porosity, bulk density, and grain size and for analysis of Fractional Organic Carbon (FOC).

A minimum of two samples for chemical analysis will be collected from each boring advanced during the NAPL investigation (original 3 borings and all step out borings completed). The soil sampling protocol is presented below:

- One soil sample will be collected from the soil/bedrock interface
- A soil sample will be collected from all intervals that show signs of NAPL
- If NAPL is not observed, then one soil sample will be collected from the most impacted portion of the boring based on PID, visual and olfactory observations.

Each soil sample will be analyzed for VOCs, SVOCs, and Total Organic Carbon (TOC). A summary of the laboratory analyses for each boring is presented in Table 3.

Sampling tools and equipment should be thoroughly cleaned as described in Attachment 13 below, or be of the disposable, single use variety. Sampling tools such as trowels and knives should be made of non-reactive materials.

3.2 MONITORING WELL INSTALLATION

Monitoring wells will be installed in three of the soil borings associated with the NAPL investigation which do not show indications of the presence of NAPL. Unless they appear to contain NAPL, a monitoring well will be installed in each of the original three borings. If they appear to contain NAPL and the stepouts borings are completed, the well will be installed in one of the corresponding stepout locations that do not contain evidence of NAPL. If the step-out locations contain NAPL, then they will be grouted closed and no well will be installed. Soil borings will be advanced at selected locations using rotasonic drilling equipment and 2-inch diameter monitoring wells will be installed as described in Section 2.1.

3.3 NAPL SAMPLING

NAPL samples will be collected for laboratory measurement of chemical properties from Leach-P-1. A disposable polyethylene bailer will be used to retrieve the NAPL from the well. This NAPL sample will be collected by directly discharging the NAPL into the laboratory supplied sample containers. Each container will be labeled with a sample identification number, site name, sampler's initials, date and time of sample collection, preservative, and the parameters to be analyzed. After sample collection, each label will be sealed with clear polyethylene tape and the samples will be logged on a chain-of-custody form, packaged to prevent damage during shipment, and cooled with ice to 4°C. Along with the corresponding chain-of-custody form, each sample will be shipped via an overnight delivery service to the laboratory. These samples will be submitted for laboratory analysis of VOCs, SVOCs, pesticides, herbicides, PCBs, dioxin, and metals.

3.4 MONITORING WELL GAUGING/OBSERVATION

The three monitoring wells installed as part of the NAPL Investigation will be gauged/observed once per month for six months or until NAPL is identified, to evaluate the possible presence of LNAPL and DNAPL. At each well, the survey will include measurement of the depth to water to the nearest 0.01 ft and a check for the presence of LNAPL or DNAPL using an electronic interface probe. The interface probes will be decontaminated between wells as described in Attachment 13.

In addition, as a visual check for LNAPL, a disposable clear bailer made of Teflon or PVC will be lowered to the water level in each well and then inspected for the presence or absence of LNAPL. A visual check for DNAPL will be performed by lowering a weighted cotton string to the bottom of the well, then retrieving the string to inspect for evidence of staining. Finally, the disposable bailer will be lowered to the bottom of each well to check for the presence of accumulated DNAPL. New string, bailers, and bailer cord will be used at each well.

4.1 SCHEDULE

It is assumed that receipt of the USEPA's approval of the Phase 2 and 3 Work Plan will be received prior to April 10, 2006. Assuming approval is received, a site walk will be conducted during the week of April 10, 2006 with Sauget Area 2 Sites Group, and CH2MHill. Prior to the site walk, each sampling location will be marked so that CH2MHill can evaluate and approve of each location during the site walk. In addition, mobilization will occur the week of April 10, 2006 and field work will begin the week of April 17, 2006. It is anticipated that the field work will take approximately 3 months to complete. An estimated time schedule is provided in Table 4.

4.2 COMMUNICATIONS PLAN

Field decisions will have to be made as part of the NAPL Investigation. In order to make these decisions in a timely and efficient manner, a communication plan will be necessary.

During the implementation of the NAPL Investigation, URS will have a total of three people on-site. Two of these people will be working directly with the drill rig and drill crew and will have the responsibility to log the boring, perform the field screening tests, collect the various samples, and decide if NAPL is present. The third person will be a field manager who will be responsible for working with the URS crew associated with the drilling and the CH2MHill oversight personnel to decide if NAPL is present. It is assumed that CH2MHill will have at least one oversight person present during the entire NAPL Investigation.

Due to the complexity of the NAPL screening and decision process, it is assumed that the URS team leader, field manager and the CH2MHill oversight person will have the technical ability to decide if NAPL is present within a boring. In addition, both the URS and CH2MHill representatives will have the authority to make the appropriate field decisions so that the project can move forward and avoid unnecessary downtime.

New Jersey Department of Environmental Protection. 1993. Hydrophobic Dye Test for Determination of NAPL in Saturated Soils and Groundwater Samples. Prepared by the Site Remediation Programs Hazardous Site Science Element Division.

Sudan IV; MSDS No. C.I.26105; Mallinckrodt Baker: Phillipsburg, NJ, November 10, 2005.

Cheiron Resources Ltd. (-NA-). *Oil Screen Soil Sudan IV Field Screening Test Instruction Manual*. Calgary, AV: Cheiron Resourced Ltd.

Table 1
Summary of Proposed Phase 2 Monitoring Well Locations
Sauget Area 2 - Supplemental Investigation

Well ID	Analytical Parameters	Hydrologic Unit
SITE P		
SA2-MW-1-S	VOC, SVOC, Metals, Herbicides, Ammonia	SHU
SA2-MW-1-M	VOC, SVOC, Metals, Herbicides, Ammonia	MHU
SA2-MW-1-D	VOC, SVOC, Metals, Herbicides, Ammonia	DHU
SA2-MW-2-S	VOC, SVOC, Metals, Herbicides, Ammonia	SHU
SA2-MW-2-M	VOC, SVOC, Metals, Herbicides, Ammonia	MHU
SA2-MW-2-D	VOC, SVOC, Metals, Herbicides, Ammonia	DHU
SITE Q NORTH/CENTRAL		
SA2-MW-6-S	VOC, SVOC, Metals, Herbicides, Ammonia	SHU
SA2-MW-6-M	VOC, SVOC, Metals, Herbicides, Ammonia	MHU
SA2-MW-6-D	VOC, SVOC, Metals, Herbicides, Ammonia	DHU
SITE Q CENTRAL		
SA2-MW-7-M	VOC, SVOC, Metals, Herbicides, Ammonia	MHU
SA2-MW-7-D	VOC, SVOC, Metals, Herbicides, Ammonia	DHU
SA2-MW-8-D	VOC, SVOC, Metals, Herbicides, Ammonia	DHU
SITE Q SOUTH		
SA2-MW-9-M	VOC, SVOC, Metals, Herbicides, Ammonia	MHU
SA2-MW-9-D	VOC, SVOC, Metals, Herbicides, Ammonia	DHU
SA2-MW-10-S	VOC, SVOC, Metals, Herbicides, Ammonia	SHU
SA2-MW-10-M	VOC, SVOC, Metals, Herbicides, Ammonia	MHU
SA2-MW-10-D	VOC, SVOC, Metals, Herbicides, Ammonia	DHU
UPGRADIENT/OFFSITE		
SA2-MW-3-S	VOC, SVOC, Metals, Herbicides, Ammonia	SHU
SA2-MW-3-M	VOC, SVOC, Metals, Herbicides, Ammonia	MHU
SA2-MW-3-D	VOC, SVOC, Metals, Herbicides, Ammonia	DHU
SA2-MW-5-S	VOC, SVOC, Metals, Herbicides, Ammonia	SHU
SA2-MW-5-M	VOC, SVOC, Metals, Herbicides, Ammonia	MHU
SA2-MW-5-D	VOC, SVOC, Metals, Herbicides, Ammonia	DHU
CLAYTON CHEMICAL		
SA2-MW-4-S	VOC, SVOC, Metals, Herbicides, Ammonia	SHU
SA2-MW-4-M	VOC, SVOC, Metals, Herbicides, Ammonia	MHU
SA2-MW-4-D	VOC, SVOC, Metals, Herbicides, Ammonia	DHU

Note: Exact depths and screen intervals to be calculated once the actual locations are determined in the field.
Wells will be screened within the appropriate hydrogeologic unit, based upon the surface elevation.

Table 2
Summary of Proposed Phase 2 Groundwater Profiling Locations
Sauget Area 2 - Supplemental Investigation

Well ID	Analytical Parameters	Hydrologic Unit
SITE P		
AA-P-10	VOC, SVOC, Herbicides, Metals, Ammonia	SHU, MHU, DHU
UPGRADIENT		
UAA-11	VOC, SVOC, Herbicides, Metals, Ammonia	SHU, MHU, DHU
OFFSITE		
OSAA-1	VOC, SVOC, Herbicides, Metals, Ammonia	SHU, MHU, DHU

Table 3
Summary of Proposed Phase 3 NAPL Investigation Locations
Sauget Area 2 - Supplemental Investigation

WELLS					
Well ID	**NAPL Sample**	**Groundwater Sample**			
SITE P					
Leach-P-1	VOCs, SVOCs, Pesticides, Herbicides, PCBs, Dioxin, Metals	Not collected			
SONIC 5					
MW-NI-A	Not collected	Not collected			
MW-NI-B	Not collected	Not collected			
MW-NI-C	Not collected	Not collected			
SOIL BORINGS					
	Field Screening		Soil Samples		
	PID	Sudan IV	Geotech	FOC	Chemical
SONIC 5					
NAPL-A	2-foot intervals	1 per 10' core	3-clean	3-clean	1 @ soil/bedrock interface. All NAPL or most impact if no NAPL - VOCs, SVOCs, TOC
NAPL-A1	2-foot intervals	1 per 10' core	Not collected	Not collected	1 @ soil/bedrock interface. All NAPL or most impact if no NAPL - VOCs, SVOCs, TOC
NAPL-A2	2-foot intervals	1 per 10' core	Not collected	Not collected	1 @ soil/bedrock interface. All NAPL or most impact if no NAPL - VOCs, SVOCs, TOC
NAPL-B	2-foot intervals	1 per 10' core	3-clean	3-clean	1 @ soil/bedrock interface. All NAPL or most impact if no NAPL - VOCs, SVOCs, TOC
NAPL-B1	2-foot intervals	1 per 10' core	Not collected	Not collected	1 @ soil/bedrock interface. All NAPL or most impact if no NAPL - VOCs, SVOCs, TOC
NAPL-C	2-foot intervals	1 per 10' core	3-clean	3-clean	1 @ soil/bedrock interface. All NAPL or most impact if no NAPL - VOCs, SVOCs, TOC
NAPL-C1	2-foot intervals	1 per 10' core	Not collected	Not collected	1 @ soil/bedrock interface. All NAPL or most impact if no NAPL - VOCs, SVOCs, TOC
NAPL-C2	2-foot intervals	1 per 10' core	Not collected	Not collected	1 @ soil/bedrock interface. All NAPL or most impact if no NAPL - VOCs, SVOCs, TOC

Table 4
Phase 2 and 3 Schedule
Sauget Area 2

Activity	**Duration**	**Cummulative Duration** From agency approval	**Date Range**[1]
Pre-Field Work Site Visit	NA	NA	Week of April 10
NAPL Investigation	2 weeks	2 weeks	April 17 – April 28, 2006
Monitoring Well Installation	5 weeks	7 weeks	May 1 – June 2, 2006
Groundwater Profiling	1 week	NA	May 1 – June 2, 2006
Monitoring Well Gauging	1 week	8 weeks	June 5 – June 9, 2006
Monitoring Well Development	2 weeks	10 weeks	June 12 – June 23, 2006
Monitoring Well Sampling	3 weeks	13 weeks	June 26 – July 14, 2006

Notes:

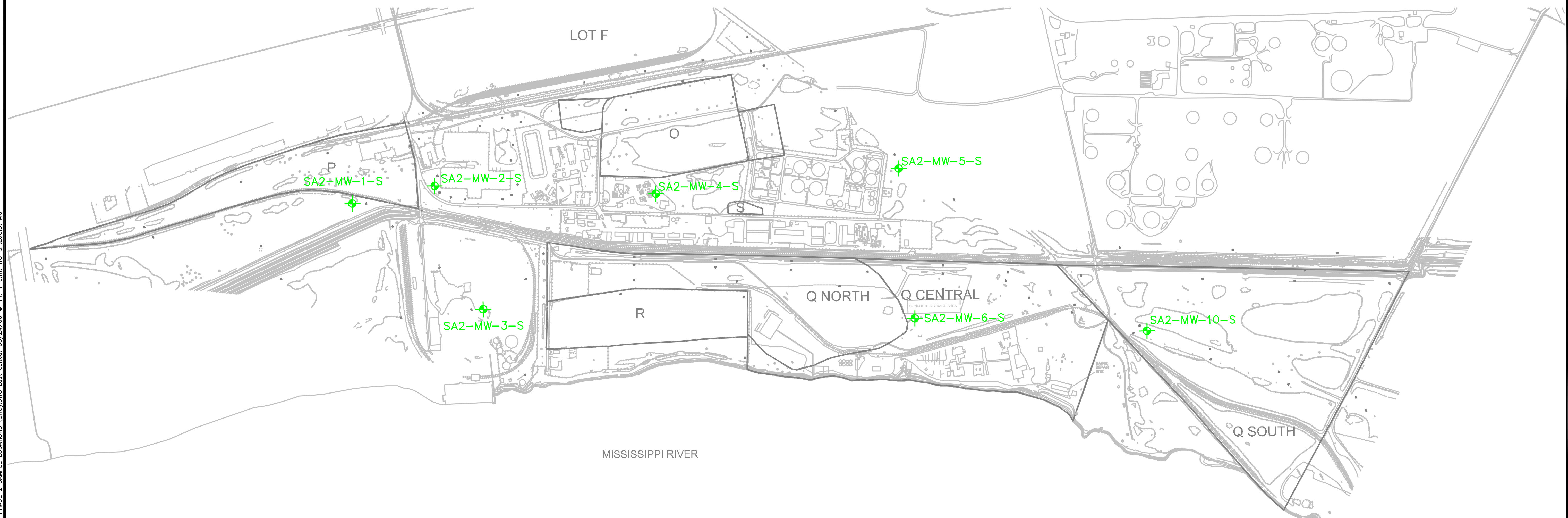
1. The dates provided are estimated based upon the estimated length of each activity. The specific scopes of work for all activities that follow Phase I have not been determined, therefore, the estimated duration and exact timeframe for each activity are subject (and likely) to change as the project progresses.

Table 5
Major Deliverables Schedule
Sauget Area 2

Deliverable	Schedule[1]
Completion of Phase I field work	August 2005 – Completed
Submission of Phase 2/3 work plan	March 2006 – Completed
Completion of Phase 2/3 field investigation	90 Days Following EPA Approval of Work Plan if approved by April 10, 2006[2] 120 Days Following EPA Approval of Work Plan, if approved on or after April 10, 2006
Submission of Phase 2/3 Data Summary	95 Days Following Completion of Field Investigation
Revised Draft RI/FS[3] Submit Groundwater Model (Flow/Fate & Transport) Submit Revised Human Health/Eco Risk Assessment Submit Revised Text RI/FS	 90 Days Following EPA Approval of Phase 2/3 Data 90 Days Following EPA approval of GW Model 90 Days Following EPA approval of Risk Assessments
Submit Final RI/FS	90 Days Following EPA Comments on Draft RI/FS

Notes:

1. The durations of each activity provided are estimates. The specific scopes of work for all activities that follow Phase 2/3 have not been determined, therefore, the estimated duration for each activity is subject (and likely) to change as the project progresses.
2. The scheduled start date of April 17, 2006 is dependent upon receipt of EPA approval of the Phase 2 and 3 Work Plan prior to April 10, 2006. If approval is not received by April 17, 2006, new mobilization dates will need to be scheduled adding an additional 30 days (estimated).
3. This assumes that the risk assessment protocols and ground water model plans are approved by EPA before the submissions of the Phase 2/3 data summary.



LEGEND

PHASE II GROUNDWATER MONITORING WELL

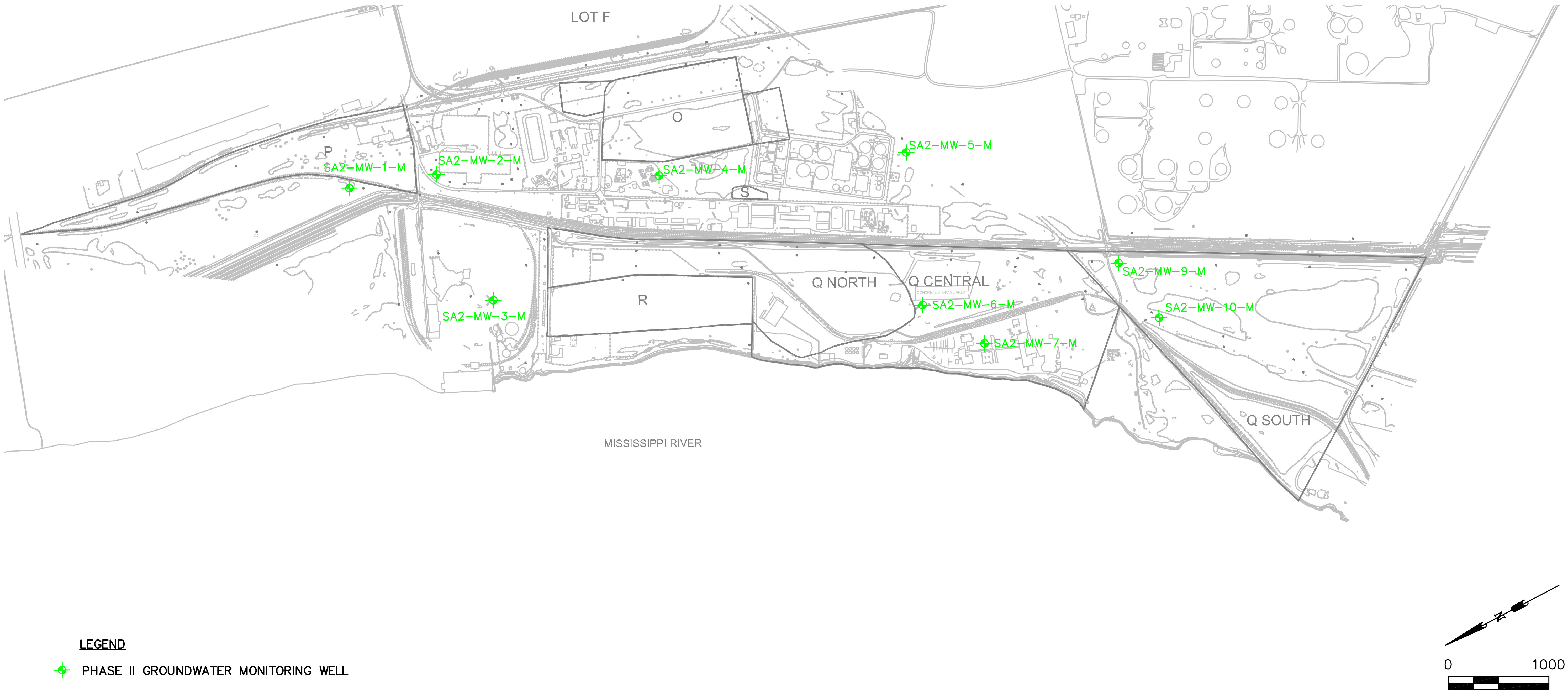
N

0 1000

SCALE FEET

SAUGET AREA 2 SAUGET, ILLINOIS	PROJECT NO. 21561510
URS	
DRN. BY: jmr 01/03/06 DSGN. BY: CHKD. BY:	Proposed Phase 2 Groundwater Sample Locations (SHU) — FIG. NO. 1

File: P:\ENVIRONMENTAL\21561510 (SA2)\WORK PLANS\SI PHASE 2 AND 3 WORK PLAN\FIGURES\FIG-1 PROPOSED PHASE 2 SAMPLE LOCATIONS (SHU).DWG Last edited: 03/24/06 @ 11:11 a.m. WC-ST.LOUIS, MO

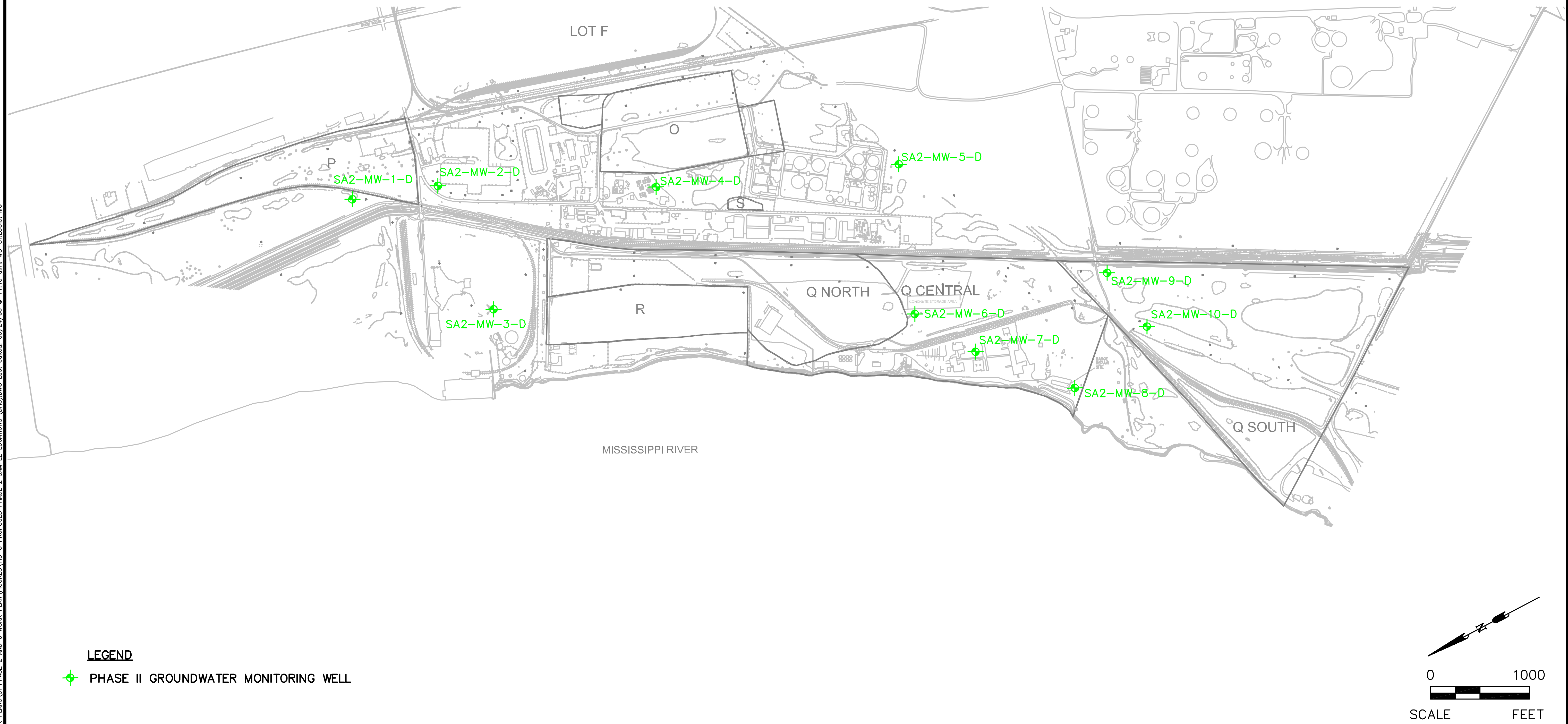


LEGEND

PHASE II GROUNDWATER MONITORING WELL

SAUGET AREA 2 SAUGET, ILLINOIS		PROJECT NO. 21561510
URS		
DRN. BY: jmr 01/03/06 DSGN. BY: CHKD. BY:	Proposed Phase 2 Groundwater Sample Locations (MHU)	FIG. NO. 2

File: P:\ENVIRONMENTAL\21561510 (SA2)\WORK PLANS\SI PHASE 2 AND 3 WORK PLAN\FIGURES\FIG-2 PROPOSED PHASE 2 SAMPLE LOCATIONS (MHU).DWG Last edited: 03/24/06 @ 11:14 a.m. WC-ST.LOUIS, MO



LEGEND

PHASE II GROUNDWATER MONITORING WELL

SAUGET AREA 2 SAUGET, ILLINOIS		PROJECT NO. 21561510
URS		
DRN. BY: jmr 01/03/06 DSGN. BY: bmh CHKD. BY:	Proposed Phase 2 Groundwater Sample Locations (DHU)	FIG. NO. 3

File: P:\ENVIRONMENTAL\21561510 (SA2)\WORK PLANS\SI PHASE 2 AND 3 WORK PLAN\FIGURES\FIG-3 PROPOSED PHASE 2 SAMPLE LOCATIONS (DHU).DWG Last edited: 03/24/06 @ 11:15 a.m. WC-ST.LOUIS, MO

LEGEND
PHASE II GROUNDWATER PROFILE LOCATION

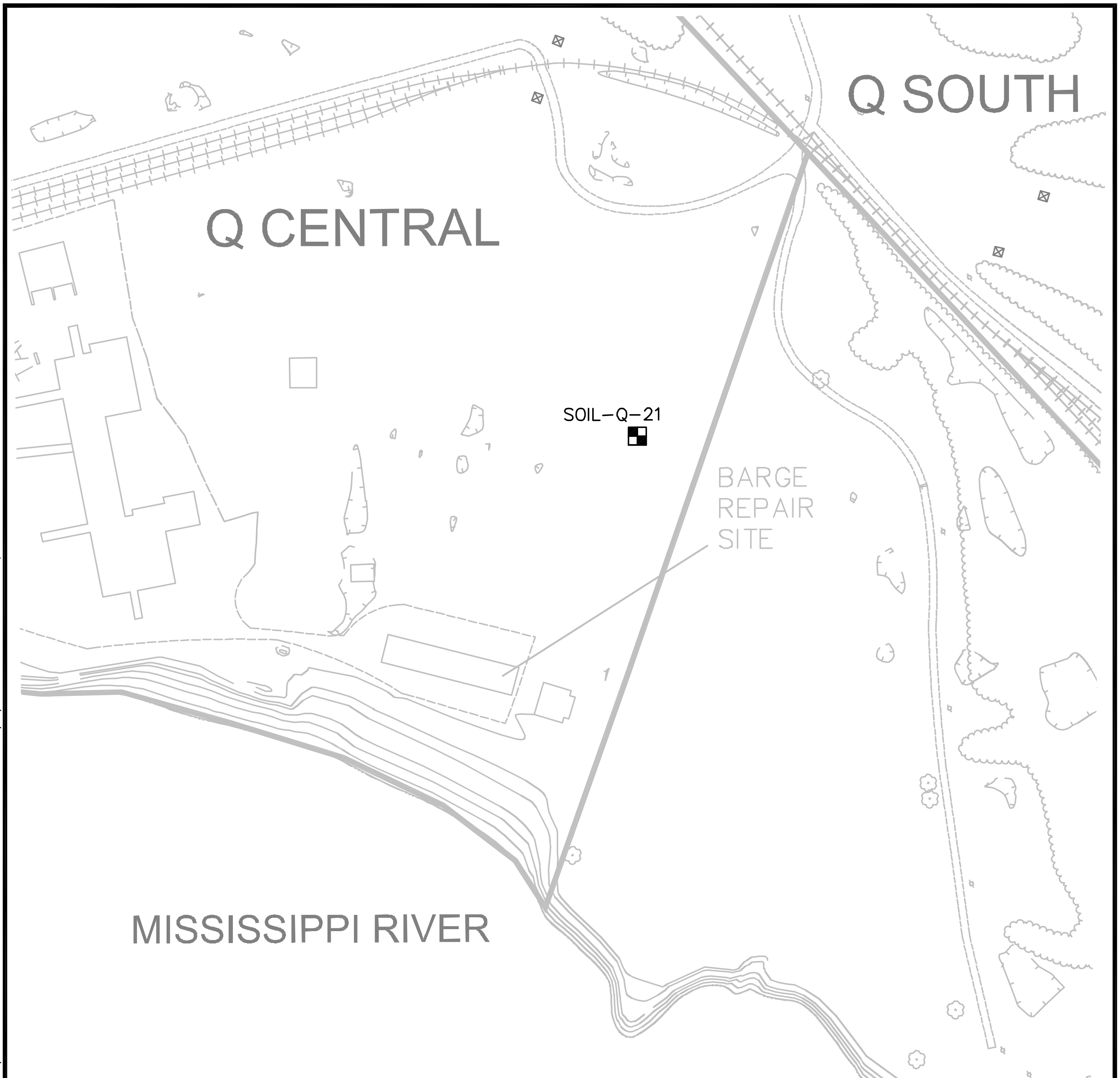
SOURCE:
MAP TAKEN FROM GOOGLE EARTH 2005.

0 1000
SCALE FEET

N

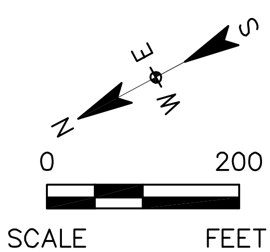
SAUGET AREA 2 SAUGET, ILLINOIS		PROJECT NO. 21561510
URS		
DRN. BY: jmr 01/03/06 DSGN. BY: bmh CHKD. BY:	Proposed Phase 2 Groundwater Profiling Locations	FIG. NO. 4

File: P:\ENVIRONMENTAL\21561510 (SA2)\WORK PLANS\SI PHASE 2 AND 3 WORK PLAN\FIGURES\FIG-4 PROPOSED PHASE 2 GW PROFILE LOCATIONS.DWG Last edited: MAR. 24, 06 @ 11:16 a.m. by: GUEST2



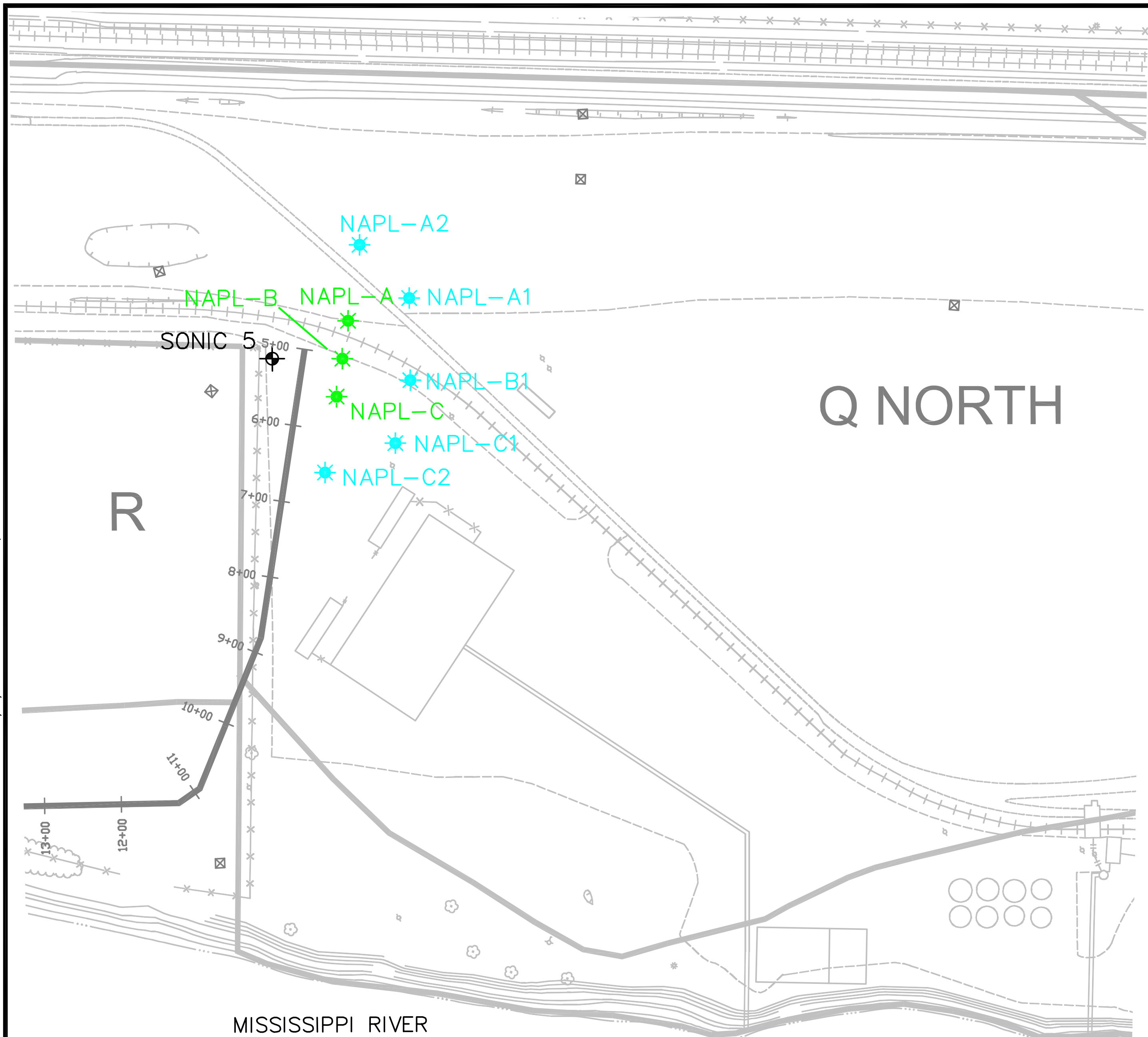
LEGEND

PROPOSED PHASE 2 SOIL BORING LOCATION



SAUGET AREA 2 SAUGET, ILLINOIS		PROJECT NO. 21561510
URS		
DRN. BY: djd 01/04/06 DSGN. BY: jmr CHKD. BY:	Proposed Phase 2 Soil Boring Location	FIG. NO. 5

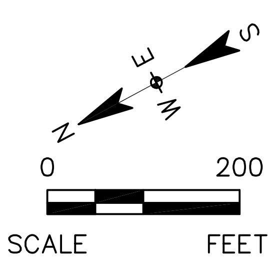
File: P:\ENVIRONMENTAL\21561510 (SA2)\WORK PLANS\SI PHASE 2 AND 3 WORK PLAN\FIGURES\FIG-5 PROPOSED PHASE 2 SOIL BORING LOCATION.DWG Last edited: 03/24/06 @ 11:17 a.m. WC-ST.LOUIS, MO



LEGEND

- EXISTING WELL AT SONIC 5 WITH OBSERVED NAPL
- PROPOSED BORING LOCATIONS
- PROPOSED STEP OUT BORING LOCATIONS
- BARRIER WALL AND STATIONS (13+00, 12+00)

Note:
Boring locations A, B, and C will be completed initially. If NAPL is identified in any of the borings, then the corresponding step out location(s) will be completed as follows:
NAPL-A -> NAPL-A1 & NAPL-A2
NAPL-B -> NAPL-B1
NAPL-C -> NAPL-C1 & NAPL-C2



SAUGET AREA 2 SAUGET, ILLINOIS	PROJECT NO. 21561510
URS	
DRN. BY: djd 01/04/06 DSGN. BY: jmr CHKD. BY:	Proposed Phase 3 NAPL Investigation Locations — FIG. NO. 6

LITHOLOGIC SAMPLING AND WELL INSTALLATION BY THE SONIC DRILLING METHOD

SCOPE AND APPLICATION

The steps and information described herein are typical procedures for carrying out lithologic sampling and well installation through sonically driven casing (SONIC drilling). All drilling and monitor well installation activities should conform to existing state environmental regulations.

SONIC DESCRIPTION

SONIC drilling involves advancing a core sample barrel or casing using resonant energy, rotation, and minimal down force to collect lithologic samples and drill a borehole. Typically, a core barrel is first sonically advanced to a selected depth, and then followed by sonic advancement of an override casing over the sample barrel to the same depth. The sample barrel is then removed and the lithologic sample extruded into a plastic sheath. The lithologic sample can then be visually examined on site for stratigraphic classification. Once the sample has been removed, the process is repeated: the sample barrel is reinserted and driven again, followed by the advancement of the override casing over the sample barrel to total depth.

Temporary protective casings can be set to allow the penetration of lower confining units, thereby eliminating the need for installation of permanent surface casings. Once the boring is complete, well installation can be accomplished inside the override casings(s). Unlike in other drilling methods, these casings are removed in reverse order by the drill rig during well installation and the annular space sealed with grout. Well installations are completed in a fraction of the time needed for conventional methods, with no potential for cross contamination between zones.

DRILLING

General Procedures

- The objective of the SONIC drilling technique is to maximize lithologic data availability, well development and performance while minimizing subsurface contamination, cross-contamination of aquifers, drilling costs, and investigation derived wastes.

- Depending on site conditions, the SONIC method may use water from an approved source to cool the bit and maintain a head pressure in the drill string to limit sand run-up. Water is added from a fresh source and is not re-circulated. When used, the water travels down the interior of the override casing (over the drill rods and sample barrel) discharging at the bit. The sample never comes in contact with such water.

Wells set in a surficial aquifer

- The sample barrel is typically advanced in 5, 10 or 20-foot intervals to collect continuous core samples of the formation.

- Once the sample barrel reaches the end of its sampling run, the override casing is advanced to the depth of the sample barrel and then the sample barrel will be removed.

- Samples are commonly extruded from the sample barrel into a plastic sample sheath by vibratory action.

- The sample barrel is then reinserted into the override casing and advanced to the base of the next sample interval.

- Sampling in this manner continues until the target depth is reached as outlined in the SOW or until a confining unit is encountered.

Wells installed into a confined aquifer

- The borings are advanced until the base of the surficial aquifer is reached.

- An override casing is then drilled to the base of the surficial aquifer.

- A new casing (heretofore known as the temporary protective casing) of a diameter one inch or greater than the override casing will then be advanced over the override casing and set two feet into the lower clay surface. The inner override casing will then be removed.

- After the first override casing is removed, if necessary, a bentonite seal can be established at the base of the temporary protective casing. This seal can be a bentonite slurry or pellets. If pellets are used sufficient time should be allotted for their complete hydration as per manufacturer specifications. The temporary protective casing should be raised approximately two feet. The seal material will then be placed in the confining formation. The temporary protective casing will then be advanced into the seal material and confining formation, enhancing the seal between the temporary protective casing drill shoe and confining formation. If needed, the temporary protective casing can be worked up and down to try to enhance the seal between the lower clay formation and drive shoe further.

- Once the seal has been established in the temporary protective casing, a pressure test can be performed to verify the seal.

- After proving the integrity of the seal, SONIC drilling into the confined aquifer continues inside the temporary protective casing.

- If deeper aquifers are to be penetrated, the preceding steps are repeated. Progressively larger temporary protective casings will be used at the base of shallower aquifers and the temporary protective casings already in place will be advanced to the base of the next lower aquifer until total depth is reached. For example, if three aquifers are to be penetrated, an 8-inch temporary casing will be advanced over the 7-inch temporary protective casing in the surficial aquifer. The 7-inch temporary protective casing would then be removed and a seal established in the 8-inch temporary protective casing as previously outlined. The 7-inch temporary protective casing will then be advanced inside the 8-inch temporary protective casing to the base of the first confined aquifer and a seal established as previously outlined. Drilling would then continue inside the 7-inch temporary protective casing into the second confined aquifer.

WELL CONSTRUCTION AND INSTALLATION

Monitor well construction methods and materials should be consistent with state regulations and in accordance with the SOW. However, the high-frequency vibrations of the SONIC method allow for modifications of the standard procedures of well installation. These modifications can enhance the placement of the filter pack and reduce development time needed to attain turbidity efficiency or production goals. In addition, vibrations induced during grout placement create a seal of sufficient integrity to allow the removal of the temporary protective casing at the end of well placement.

Filter Pack Placement

- Once the drilling has reached target depth as described above, the sample core barrel shall be removed and the well casing and screen shall be placed in the override casing. The filter pack is placed in the override casing to gravity feed, and the casing is vibrated and pulled up. The vibration of the casing helps to settle the filter sand making a compact filter pack, eliminating any potential voids or bridging.

Bentonite Seal

- Bentonite seals of specified thickness are placed inside the override casing and the casing is raised while vibrating to allow the seal to flow onto the top of the filter pack.

Grouting

- Once the bentonite seal is in place and sufficient time allowed for hydration, grouting can then take place. Grout is prepared as normal, and tremmied in the override casing. Once a column of grout is placed in the override casing, the casing is vibrated and withdrawn. By pumping the grout inside the casing and vibrating the casing as it is withdrawn, a complete filling of the annular space is accomplished. In addition, the vibration of the casing allows thorough seating or “knitting” of the grout into the formation and annular space to insure contact between the casing and borehole wall.

- For wells installed in a confined aquifer, grouting as outlined above continues until the top of the confining layer is reached. Once the top of the confining layer is reached, the inner override casing shall be completely withdrawn. At this point grouting resumes within the next temporary protective casing. If more than one confining layer was penetrated, grouting using the temporary protective casing is performed until the top of the next confining layer is reached. The temporary protective casing is withdrawn and grouting continues inside the next temporary protective casing. This method continues until ground surface is reached.

1. *Objective*

This document defines the standard procedure for logging of soil and rock samples both for environmental and geotechnical characterization purposes. This procedure provides descriptions of equipment and field procedures necessary to log soil and rock samples. Other related SOPs are listed below:

- SOP No. 8 – Field Reporting and Documentation.
- SOP No. 28 – Soil Sampling

2. *Equipment*

The following equipment is typically used during soil and rock sample logging:

- USCS Chart
- Boring logs
- Tape measure
- Tore Vain
- Pocket Penetrometer
- Field data sheets/bound field logbook
- Waterproof ink.

3. *Sample Descriptions*

This section provides an approach for describing (logging) soil samples in the field. General observations made before, during, and after field activities should be recorded in a bound field logbook in accordance with the procedures defined in SOP No. 8 on field reporting and documentation:

Soil

The soil's description should include as a minimum:

- Apparent consistency (for fine-grained soils) or density (for coarse-grained soil) adjective
- Water content condition adjective
- Color description
- Minor soil type name with "y" added (if ≥ 30 percent)

- Descriptive adjective for main soil type
  - Particle-size distribution adjective for gravel and sand
  - Plasticity adjective and soil texture (silty or clayey) for inorganic and organic silts or clays
- Main soil type's name (all capital letters)
- Descriptive adjective, some or trace, for minor soil type if ≤ 30 percent
- Minor soil type(s)
- Inclusions
- The Unified Soil Classification System (USCS) Group Name and Symbol appropriate for the soil type in accordance with ASTM D 2487, with few exceptions, and (symbol in parenthesis)
- Geologic name, if known (in parenthesis or in notes column)

The various elements of the soil's description should be stated in the order listed above.

Examples:

Fine-grained soils	Soft, wet, gray, high plasticity CLAY, trace f. sand – Fat CLAY (CH); (Alluvium)
Coarse-grained soils	Dense, moist, brown, silty m-f SAND, trace f. gravel to c. sand – Silty SAND (SM); (Alluvium)

When changes occur within the same soil layer, such as change in apparent density, then this is indicated by means of a bent arrow, point downward (↴) and a description of the change. Note that only those aspects of the soil description that are different from the description of the overlying soil are mentioned. Note also that the depth at which some characteristic is no longer present must be noted.

Apparent Consistency and Density

Consistency and density descriptive terms are related to blow count resistance using a 2-inch OD, 24-inch long split barrel sampler and standard penetration tests (a 140-pound hammer dropped 30-inches) (ASTM D 1586-84). Use the values and descriptions in the table presented below to determine the consistency and density.

Consistency & Density

Cohesive Clays (clays & silts)		Non-cohesive Granular Soils (sands & gravels)	
0-2	Very soft	0-4	Very loose
3-4	Soft	4-10	Loose
5-8	Medium stiff	11-30	Medium dense
9-15	Stiff	31-50	Dense
16-30	Very stiff	>50	Very dense
>30	Hard		

A blow count of >50 for a 12-inch interval constitutes spoon refusal and the sample should be terminated at that time.

The strength of the soil can be determined without blow counts using the following guide:

H Hard Soil – Brittle or tough, may be broken in the hand with difficulty. Can be peeled with a pocketknife.

VST Very Stiff – Soil can barely be imprinted by pressure from the fingers or indented by thumbnail.

ST Stiff – Soil can be imprinted with considerable pressure from fingers or indented by thumbnail.

M Medium Stiff – Soil can be imprinted easily with fingers; remolded by strong finger pressure.

So Soft – Soil can be pinched in two between the thumb and forefinger; remolded by light finger pressure.

Vso Very Soft – Soil exudes between fingers when squeezed; specimen (height = 2 x diameter) sags under its own weight.

Water Content

The amount of water present in the soil sample or its water content adjective should be described as dry, moist, or wet as follows:

Descriptors for Water Content (moisture)

Description	Condition
Dry	No sign of water and soil is dry to the touch
Moist	Signs of water and soil is relatively dry to the touch
Wet	Signs of water and the soil definitely wet to the touch; granular soil exhibits some free water when densified

The descriptor "damp" should not be used (use "moist"). The descriptor "saturated" should not be used (use "wet").

Color

The colors should be assigned consistent with a Munsell Color Chart and should be described when the sample is first retrieved at the soil's as-sampled water content (the color will change with water content). A Munsell Color Chart is provided as Appendix A. When the soil is marked with spots of color, the term mottled can be applied with the following descriptors:

Descriptors for Mottling

Abundance	Size	Contract
f: few (<2%)	fine (<5 mm)	faint
c: common (2%-20%)	medium (5-15 mm)	distinct
m: many (>20%)	coarse (>15 mm)	prominent

Soils with a homogeneous texture but having color patterns, which change and are not considered mottled, can be described as streaked.

Soil Types

The constituent parts of a given soil type are defined on the basis of texture in accordance with particle-size designators separating the soil into coarse-grained, fine-grained, and highly organic designations.

Coarse-grained (gravel and sand)

Soils with more than 50% of the particles larger than No. 200 sieve (0.074 mm). The soil components are described on the basis of particle size as follows:

Grade Limits and Grade Standards

Grade Names	
Name	**Grain Size**
Sand	
fine	#200 to #40 sieve
medium	#40 to #10 sieve
coarse	#10 to #4 sieve
Gravel	
fine	#4 sieve to ¾-inch
coarse	¾-inch to 3-inches
Cobbles	3-inches to 12-inches
Boulders	>12-inches

The particle-size distribution is identified as well graded or poorly graded. Well-graded coarse-grained soil contains a good representation of all particle sizes from largest to smallest, with ≤12 percent fines. Poorly graded coarse-grained soil is uniformly graded with most particles about the same size or lacking one or more intermediate sizes, with ≤12 percent fines. A table of USC symbols and names for coarse-grained soils is presented below.

USCS Symbols and Names for Coarse-grained Soils

USCS Symbol	Typical Names
GW	Well graded gravels, gravel-sand mixtures, little or no fines
GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures
SW	Well graded sands, gravelly sands, little or no fines

USCS Symbols and Names for Coarse-grained Soils

USCS Symbol	Typical Names
SP	Poorly graded sands, gravelly sands, little or no fines
SM	Silty sand, sand-silt mixtures
SC	Clayey sands, sand-clay mixtures

The following field identification tests can be used to estimate the grain size distribution of coarse-grained soils:

Feel and Smear Tests – A pinch of soil is handled lightly between the thumb and fingers to obtain an impression of the grittiness or of the softness of the constituent particles. Thereafter, a pinch of soil is smeared with considerable pressure between the thumb and forefinger to determine the degrees of roughness and grittiness, or the softness and smoothness of the soil.

Coarse- to medium-grained sand:	Typically exhibits a very harsh and gritty feel and smear.
Coarse- to fine-grained sand:	Has a less harsh feel, but exhibits a very gritty smear.
Medium- to fine-grained sand:	Exhibits a less gritty feel and smear which becomes softer and less gritty with an increase in the fine sand fraction.
Fine-grained sand:	Exhibits a relatively soft feel and a much less gritty smear than the coarser sand components.
Silt:	Components less than about 10 percent of the total weight can be identified by a slight discoloration of the fingers after smear of a moist sample. Increasing silt increases discoloration and softens the smear.

Sedimentation Test – A small sample of soil is shaken in a test tube filled with water and allowed to settle. The time required for the particles to fall to a distance of 4 inches is about ½ minute for particle sizes coarser than silt. About 50 minutes would be required for particles of 0.005 mm or smaller (often defined as "clay size") to settle out.

Visual Characteristics – Sand and gravel particles can be readily identified visually, however, silt particles are generally indistinguishable to the eye. With an increasing silt component, individual sand grains become obscured, and when silt exceeds about 12 percent, it masks almost entirely the sand component from visual separation. Note that gray fine-grained sand visually appears siltier than the actual silt content.

Fine-grained (clay and silt)

Soils with more than 50% of the particles finer than the No. 200 sieve (0.074 mm) and the fines are silts and clays.

A table of USC symbols and names for fine-grained soils is presented here.

USCS Symbols and Names for Fine-grained Soils

USCS Symbol	Typical Names
ML	Inorganic silts and very fine sands, rock flour, silty, or clayey fine sands, or clayey silts with slight plasticity
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
OL	Organic silts and organic silty clays of low plasticity
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
CH	Inorganic clays or high plasticity (residual clays), fat clays
OH	Organic clays of medium to high plasticity, organic silts
Pt	Peat and other highly organic soils

The following field identification tests can be used to estimate the degree of plasticity and size distribution of fine-grained soils:

Shaking (Dilatency) Test: Water is dropped or sprayed on a part of basically fine-grained soil mixed and held in the palm of the hand until it shows a wet surface appearance when shaken or bounced lightly in the hand or a sticky nature when touched. The test involves lightly squeezing the soil pat between the thumb and forefinger and releasing it alternatively to observe its reaction and the speed of the response. Soils which are predominantly silty (nonplastic to low plasticity) will show a dull dry surface upon squeezing and a glassy wet surface immediately upon releasing of the pressure. With increasing fineness (plasticity) and the related decreasing dilatency, this phenomena becomes less and less pronounced.

Dry Strength Test: A portion of the sample is allowed to dry out and a fragment of the dried soil is pressed between the fingers. Fragments which cannot be crumbled or broken are characteristic of clays with high plasticity. Fragments which can be disintegrated with gentle finger pressure are characteristic of silty materials of low plasticity. Thus, materials with great dry strength are clays of high plasticity and those with little dry strength are predominantly silts.

Thread Test: Moisture is added or worked out of a small ball (approximately 1 ½-inch diameter) and the ball kneaded until its consistency approaches medium stiff to stiff, it breaks, or crumbles. A thread is then rolled out to the smallest diameter possible before disintegration. The smaller the thread achieved, the higher the plasticity of the soil. Fine-grained soils of high plasticity will have threads smaller than 1/32 inch in diameter. Soils with low plasticity will have threads larger than 1/8 inch in diameter.

Smear Test: A fragment of soil smeared between the thumb and forefinger or drawn across the thumbnail will, by the smoothness and sheen of the smear surface, indicate the plasticity of the soil. A soil of low plasticity will exhibit a rough textured, dull smear while a soil of high plasticity will exhibit a slick, waxy smear surface.

The following table presents the terms used to denote the various degrees of plasticity of soil that passes the No. 200 sieve.

Degrees of Plasticity

Descriptive Term	Degree of Plasticity	Plasticity Index Range
SILT	none	non-plastic
Clayey SILT	slight	1-5
SILT & CLAY	low	5-10
CLAY & SILT	medium	10-20
Silty CLAY	high	20-40
CLAY	very high	over 40

Highly-organic

Soils primarily consisting of organic matter. Identification markers are:

1. Dark and black and sometimes dark brown colors, although not all dark colored soils are organic.

2. Moist organic soils will oxidize when exposed to air and change from a gray/black color to a lighter brown, i.e. The exposed surface is brownish, but when the sample is pulled apart the freshly exposed surface is dark gray/black.

3. Fresh organic soils usually have a characteristic odor which can be recognized, particularly when the soil is heated.

4. Compared to non-organic soils, less effort is typically required to pull the material apart and a friable break is usually formed with a fine granular or silty texture and appearance.

5. Their workability at the plastic limit is weaker and spongier than an equivalent non-organic soil.

6. The smear, although generally smooth, is usually duller and appears siltier.

A table of soil descriptors is presented below.

Soil Descriptors

Calcareous:	Containing appreciable quantities of calcium carbonate
Fissured:	Containing shrinkage cracks, often filled with fine sand or silt, usually more less vertical
Interbedded:	Containing alternating layers of different soil types
Intermixed:	Containing appreciable, random, and disoriented quantities of varying color, texture, or constituency
Laminated:	Containing thin layers of varying color, texture, or constituency
Layer:	Thickness greater than 3 inches
Mottled:	Containing appreciable random speckles or pockets of varying color, texture, or constituency
Parting:	Paper thin
Poorly graded (well sorted):	Primarily one grain size, or having a range of sizes with some intermediate size missing
Slickensided:	Having inclined planes of weakness that are slick and glossy in appearance and often result in lower unconfined compression cohesion
Split graded:	Containing two predominant grain sizes with intermediate sizes missing

Soil Descriptors

Varved:	Sanded or layered with silt or very fine sand (cyclic sedimentary couplet)	
Well graded (poorly sorted):	Containing wide range of grain sizes and substantial amounts of all intermediate particle sizes	
Modifiers:	Predominant type -	50% to 100%
	Modifying type -	12% to 50%
	With -	5% to 12%
	Trace -	1% to 5%

Minor Soil Types

In many soils two or more soil types are present in the soil. When the percentage of the minor soil type is ≥ 30% and < 50% of the total sample, the minor soil type is given prior to the major soil type and is indicated by adding a "y" to its name; i.e. silty CLAY.

When the minor soil type percentage is between 1 and 29% of the total sample, the minor soil type is given after the major soil type is given along with an adjective term:

1. Trace – When the soil type's percentage is between 1 and 12% of the total sample.
2. Some – When the soil type's percentage is between 13 and 29% of the total sample.

Inclusions

Additional inclusions or characteristics of the sample can be described by using "with" and the descriptions described above. Examples are given below:

1. With petroleum odor
2. With organic matter
3. With shell fragments
4. With mica.

Layered Soils

Soils of different types can be found in repeating layers of various thicknesses. It is important that all such formations and their thicknesses are noted. Each layer is described as if it is a nonlayered soil using the sequence for soil descriptions discussed above. The thickness and shape of layers and the geological type of layering are noted using the following descriptive terms:

Type of Layer	Thickness	Occurrence
Parting	< 1/16 inch	
Seam	1/16 inch to 0.5 inches	
Layer	0.5 inches to 12 inches	
Stratum	> 12 inches	
Pocket		Small erratic deposit
Lens		Lenticular deposit
Varved (also layered)		Alternating seams or layers of silt and/or clay and sometimes fine sand
Occasional		One or less per foot of thickness of laboratory sample inspected
Frequent		More than one per foot of thickness of laboratory sample inspected

Place the thickness designation before the type of layer, or at the end of each description and in parentheses, whichever is appropriate.

An example of a description of layered soils is:

> Medium stiff, moist to wet ¼” – ¾” interbedded seams and layers of: gray, medium plastic, silty CLAY (CL); and lt. gray, low plasticity SILT (ML); (Alluvium).

Geologic Name

The soil description should include the Field Representative's assessment of the origin of the soil unit and the geologic name, if known, placed in parentheses at the end of the soil description or in the field notes column of the boring log.

A copy of the boring log to be used is included as Appendix B.

Rock

The rock's description should include as a minimum:

- Rock type
- Color
- Grain size and shape
- Texture (stratification/foliation)
- Mineral composition
- Weathering and alteration
- Strength
- Other relevant notes.

The various elements of the rock's description should be stated in the order listed above.

Example:

Limestone, light gray, very fine-grained, thin-bedded, unweathered, strong

The rock description should include identification of discontinuities and fractures. The description should include a drawing of the naturally occurring fractures and mechanical breaks.

Rock Type

Rocks are classified according to origin into three major divisions: igneous, sedimentary, and metamorphic. These three groups are subdivided into types according to mineral and chemical composition, texture, and internal structure. Engineering classifications of rocks can be based on ASTM Method C 294.

Division	Class	Type
Igneous	Coarse-grained (Intrusive)	Granite Syenite Diorite Gabbro Peridotite Pegmatite
	Fine-grained (Extrusive)	Volcanic Glass Delsite Basalt
Sedimentary Sedimentary (con't.)	Calcareous	Limestone Dolomite
	Siliceous	Conglomerate Sandstone Quartizite Claystone Siltstone Argillite Shale Chert
Metamorphic	Foliated	Slate Phyllite Schist Amphibolite Hornfers Unfixes
	Nonfoliated	Marble Metaquartzite Serpentinite

Color

Colors should be assigned consistent with a Munsell Color Chart and recorded for both wet and dry conditions as appropriate. A Munsell Color Chart is provided as Appendix A.

Grain Size and Shape

The grain size description should be classified using the following terms:

Very Coarse-Grained:	Diameter greater than 0.187 inches (4.76 mm).
Coarse-Grained:	Diameter 0.187 inches to 0.0787 inches (4.76 mm to 2.00 mm). Individual grains can be easily distinguished by the naked eye.
Medium-Grained:	Diameter 0.0787 inches to 0.0165 inches (2.00 mm to 0.420 mm). Individual grains can be distinguished with the naked eye.
Fine-Grained:	Diameter 0.0165 inches to 0.0029 inches (0.420 mm to 0.074 mm). Individual grains can be distinguished by the naked eye with difficulty.
Very Fine-grained:	Diameter less than 0.0029 inches (0.074 mm). Individual grains cannot be distinguished by the naked eye.

The grain shape description should be classified using the following terms:

Angular:	Showing very little evidence of wear. Grain edges and corners are sharp. Secondary corners are numerous and sharp.
Subangular:	Showing definite effects of wear. Grain edges and corners are slightly rounded off. Secondary corners are slightly less numerous and slightly less sharp than in angular grains.
Subrounded:	Showing considerable wear. Grain edges and corners are rounded to smooth curves. Secondary corners are reduced greatly in number and highly rounded.
Rounded:	Showing extreme wear. Grain edges and corners are smoother off to broad curves. Secondary corners are few in number and rounded.
Well-Rounded:	Completely worn. Grain edges or corners are not present. No secondary edges or corners are present.

Texture (stratification/foliation)

Significant nonfracture structural features should be described. The thickness should be described using the following terms:

Type of Layer	Thickness	
	English	**Metric**
Thinly laminated	0.1 inches	2.5 millimeters
Laminated	0.1 to 0.5 inches	2.5 to 10 millimeters
Very thinly bedded	0.5 to 2.0 inches	1 to 5 centimeters
Thinly bedded	2.0 inches to 2 feet	5 to 50 centimeters
Thickly bedded	2 to 3 feet	0.5 to 1 meters
Very thickly bedded	3 feet	1 meter

The orientation of the bedding/foliation should be measured from the horizontal with a protractor.

Mineral Composition

A geologist based on experience and the use of appropriate references should identify the mineral composition. The most abundant mineral should be listed first, followed by minerals in decreasing order of abundance. For some common rock types, mineral composition need not be specified (i.e. dolomite, limestone).

Weathering and Alteration

Weathering as defined here is due to physical disintegration of the minerals in the rock by atmospheric processes while alteration is defined here as due to geothermal processes. Terms and abbreviations used to describe weathering or alteration are:

RS Residual Soil – The original minerals of the rock have been entirely weathered to secondary minerals, and the original rock fabric is not apparent. The material can be easily broken.

C Completely Altered or Weathered – The original minerals of the rock have been almost entirely changed to secondary minerals, even though the original fabric may be intact. The material can be easily broken.

H Highly Altered or Weathered – The rock is weakened to such an extent that a sample with a 2-inch minimum diameter can be broken readily by hand across the rock fabric. More than half the rock material is decomposed or altered. Fresh rock is present in a discontinuous framework or as corestones.

M Moderately Altered or Weathered – rock is discolored and noticeably weakened, but sample with a 2-inch minimum diameter cannot usually be broken by hand, across the rock fabric. Less than half of the rock material is decomposed or altered. Fresh or discolored rock is present either as a continuous framework or as corestones.

S Slightly Altered or Weathered – Rock is slightly discolored, but not noticeably lower in strength than fresh rock.

F Fresh – Rock shows no discoloration, no loss of strength, or any other effect of weathering.

Strength

A common qualitative assessment of strength can be used while logging of rock core during drilling. Terms and abbreviations used to describe weathering or alteration are:

ES Extremely Strong – Specimen can only be chipped with geological hammer.

VS Very Strong – Specimen requires many blows of geologic hammer to fracture it.

S Strong – Specimen requires more than one blow of geological hammer to fracture it.

MS Medium Strong – Cannot be scraped or peeled with a pocketknife. Specimen can be fractured with a single firm blow of geological hammer.

W Weak – material crumbles under firm blows with the sharp end of a geological hammer. Can be peeled by a pocketknife with difficulty.

VW Very Weak Rock – Brittle or tough, may be broken in the hand with difficulty. Can be peeled with a pocketknife.

Descriptors and abbreviations used to describe rock hardness are:

S Soft - Reserved for plastic material alone.

F Friable - Easily crumbled by hand, pulverized or reduced to powder and is too soft to be cut with a pocketknife.

LH Low Hardness - Can be gouged deeply or carved with a pocketknife.

MH Moderately Hard - Can be readily scratched by a knife blade; scratch leaves heavy trace of dust and scratch is readily visible after the powder has been blown away.

H Hard - Can be scratched with difficulty; scratch produces little powder and is often faintly visible; traces of the knife steel may be visible.

VH Very Hard - Cannot be scratched with pocketknife. Leaves knife steel marks on surface.

Rock Discontinuity

Discontinuity is the general term for any mechanical discontinuity in a rock mass having zero or low tensile strength. It is the collective term for most types of joints, weak bedding planes, weak schistocity planes, weakness zones, and faults. The following symbols are recommended for the type of rock mass discontinuities.

F	Fault
J	Joint
Sh	Shear
Fo	Foliation
V	Vein
B	Bedding

The spacing of discontinuities is the perpendicular distance between adjacent discontinuities. The spacing should be measured in feet to the nearest tenth, perpendicular to the planes in the set.

EC	Extremely close spacing	<0.07 ft
VC	Very close spacing	0.07 – 0.2 ft
C	Close spacing	0.2 – 0.66 ft
M	Moderate spacing	0.7 – 2 ft
W	Wide spacing	>2 – 6.6 ft
EW	Extremely wide spacing	>6.6 ft

The discontinuities should be described as closed, open, or filled. Aperture is used to describe the perpendicular distance separating the adjacent rock walls of an open discontinuity in which the intervening space is air or water filled. Width is used to described the distance separating the adjacent rock walls of filled discontinuities. The following terms should be used to describe apertures:

Aperture	Description	
<0.1 mm 0.1 – 0.25 mm 0.2 0.25 – 0.5 mm	Very tight Tight Partly open	“Closed Features”
0.5 – 2.5 mm 2.5 – 10 mm >10 mm	Open Moderately open Wide	“Gapped Features”
1 10 cm 1 10 – 100 cm >1 m	Very wide Extremely wide Cavernous	“Open Features”

The following terms are recommended to describe the width of discontinuities such as thickness of veins, fault gouge filling, or joints openings.

W	Wide	0.5 – 2.0 inches
MW	Moderately wide	0.1 – 0.5 inches
N	Narrow	0.05 – 0.1 inches
VN	Very narrow	<0.05
T	Tight	0

For the thickness of faults or shears that are not thick enough to be represented on the boring log and are greater than 2-inches thick, record the measured thickness numerically in feet to the nearest tenth of a foot.

The following terms should be used to describe the planarity of discontinuities:

Wa	Wavy
Pl	Planar
St	Stepped
Amplitude =	A
Wavelength =	γ

Measured in feet.

The following terms should be used to describe the surface roughness of discontinuities:

VR	Very Rough – Near right-angle steps and ridges occur on the discontinuity surface.
R	Rough – Some ridges and side- angle steps are evident; asperities are clearly visible; and discontinuity surface feels very abrasive.
Sr	Slightly Rough – Asperities on the discontinuity surfaces are distinguishable and can be felt.
S	Smooth – Surface appears smooth and feels so to the touch.
Slk	Slickensides – Visual evidence of striations or a smooth glassy appearing finish.

Filling is the term for material separating the adjacent rock walls of discontinuities. The perpendicular distance between the adjacent rock walls is termed the width of the filled discontinuity. The type of discontinuity infilling should be described using the following terms:

C	Clay	Fe	Iron Oxide
Sd	Sand	g	Gypsum/Talc
H	Healed	q	Quartz
Ch	Chlorite	N	None
Ca	Calcite	O	Other (describe)

The amount of infilling in discontinuities should be described using the following terms:

St	Surface stain
Sp	Spotty
P	Partially filled half surface or opening is filled
F	Filled
N	None.

Fracture Description

The location of each naturally occurring fracture and mechanical break is shown in the fracture column of the rock core log. The naturally occurring fractures are numbered and described using the terminology described above for discontinuities.

The naturally occurring fracture and mechanical breaks are sketched in the drawing column.

Dip angles of fractures should be measured using a protractor and marked on the log. For nonvertical borings, the angle should be measured and marked as if the boring was vertical. If the rock is broken into many pieces less than ½ inch to 1-inch long, the log may be crosshatched in that interval or the fracture may be shown schematically.

The number of naturally occurring fractures observed in each foot of core should be recorded in the fracture frequency column. Mechanical breaks, thought to have occurred due to drilling, are not counted. The following criteria can be used to identify natural breaks:

1. A rough brittle surface with fresh cleavage planes in individual rock minerals indicates an artificial fracture.
2. A generally smooth or somewhat weathered surface with soft coating or infilling materials, such as talc, gypsum, chlorite, mica, or calcite obviously indicates a natural discontinuity.
3. In rocks showing foliation, cleavage or bedding it may be difficult to distinguish between natural discontinuities and artificial fractures when these are parallel with the incipient weakness planes. If drilling has been carried out carefully then the questionable breaks should be counted as natural features, to be on the conservative side.
4. Depending upon the drilling equipment, part of the length of core being drilled may occasionally rotate with the inner barrels in such a way that grinding of the surfaces of discontinuities and fractures occurs. In weak rock types it may be very difficult to decide if the resulting rounded surfaces represent natural or artificial features. When in doubt, the conservative assumption should be made; i.e., assume that they are natural.
5. It may be useful to keep a separate record of the frequency of artificial fractures (and associated lower RQD) for assessing the possible influence of blasting on the weaker sedimentary and foliated or schistose metamorphic rocks.

The results of core logging (frequency and RQD) can be strongly time dependent and moisture content dependent in the case of certain varieties of shales and mudstones having relatively weakly developed digenetic bonds. A not infrequent problem is "discing," in which an initially intact core separates into discs on incipient planes, the process becoming noticeable perhaps within minutes of core recovery. The phenomena are experienced in several different forms:

1. Stress relief cracking (and swelling) by the initially rapid release of strain energy in cores recovered from areas of high stress, especially in the case of shaley rock.

2. Dehydration cracking experienced in the weaker mudstones and shales which may reduce RQD from 100 to 0 percent in a matter of minutes, the initial integrity possibly being due to negative pore pressure.

3. Slaking cracking experienced by some of the weaker mudstones and shales when subjected to wetting.

All these phenomena make core logging of *frequency* and RQD unreliable. Whenever such conditions are anticipated, an engineering geologist should log core as it is recovered and at subsequent intervals until the phenomenon is predictable. An added advantage is that the engineering geologist can perform mechanical index tests, such as the point load or Schmidt hammer test, while the core is still in a saturated state.

5. Drilling information:

- Drill rig manufacturer, model, and driller (if applicable)
- Geologist or geotechnical engineer
- Project name, sample point identification, and location
- Date samples obtained (and times if required)
- Type of sampler (e.g., split spoon, Shelby, California), measurements or method of advancing boring or equipment, method of driving sampler, and weight of hammer
- Drill fluids (if applicable)
- Ground surface or grade elevation (if known)
- Depth penetrated and blow counts/6-inch interval of penetration for ASTM 1586-84 and sample number (if applicable)
- Closed hole intervals and advancement (if applicable)
- Recovery
- Strata changes and changes within samples
- Sampling tool behavior
- Drill string behavior
- Use(s) of borehole
- Disposition(s) of residual soil or cuttings
- Signature or sampling of log (as required).

1. Objective

This document defines the standard operating procedure for calibration and maintenance of field instruments frequently used during environmental field activities. This Standard Operating Procedure (SOP) gives descriptions of the most common used of these instruments and field procedures necessary to calibrate and maintain these field instruments. Other related SOPs are listed below:

- SOP No. 4 – Decontamination
- SOP No. 8 – Field Reporting and Documentation.

2. Equipment

The following equipment is required during field instrument calibration and maintenance activities.

- Latex/Nitrile gloves
- Site logbook
- Field data sheets
- Equipment Calibration Record forms
- Distilled/deionized water
- Decontamination equipment
- Health and Safety Equipment
- Field Instrument Operations Manual
- Calibration gases for Air Monitoring Equipment
- Calibration solutions for Water Monitoring Equipment.

3. Type of Field Instruments Commonly used during Environmental Investigations

The following are some of the more commonly used instruments during environmental investigations.

- Photoionization Detector (PID)
- Multi-gas Meter (usually includes Explosimeter, Hydrogen Sulfide detector, Oxygen sensor, and Carbon Monoxide meter)
- RAM

- Groundwater Level Indicator
- Petroleum/Groundwater Interface Probe
- Groundwater pH, Temperature, Conductivity Meter.

4. Maintenance

Maintenance of field instruments should be performed on all field instruments on a regular basis to ensure instruments are in proper working order at all times and to prolong the instruments life. General maintenance such as regular cleaning of the instrument, battery checks and replacement, and ensuring the instrument is handled and stored properly can easily be performed by URS employees. Other maintenance items such as sensor repair, annual calibrations and repair of a malfunctioning piece of equipment should be performed by the instrument manufacturer or licensed dealer and should not be performed by URS employees. Contact the manufacturer to determine where the instrument should be submitted for these maintenance tasks. The vast range of instruments available for use by the environmental professional have an equally vast maintenance regime and therefore maintenance guidelines specified in manual for each piece of equipment should be referred to and followed at all times.

5. Calibration

Due to the vast number of field instruments available, various parameters potentially monitored, and the wide range of functions potentially performed by each instrument, a description of the calibration of every type of instrument available is not feasible. However, a generalized SOP for general types of field equipment calibration is presented and should be followed while performing calibrations of field instruments.

Air Monitoring Instruments (PID, Multigas Meters, Hydrogen Sulfide Detectors, etc.)

- Turn the instrument on. The on/off switch may be a toggle switch, knob, or button to be depressed depending on the type and brand of instrument being used.
- Allow the instrument to "warm up" and progress through the startup diagnostic routine.
- Apply the calibration gas (isobutylene, methane, multi-gas mixtures, etc.) to the instrument to get an initial instrument reading.
- Record the initial reading on the proper equipment calibration field form and in the site logbook. Also record the calibration standard and concentration of that standard on the field form and in the logbook.

- If the initial reading is greater than +/-5% of the calibration standard proceed with instrument calibration as specified in the equipment operator's manual. If the initial reading is within this +/- 5% window of the calibration gas standard, the instrument should be considered calibrated and additional calibration is not required at this time. At periodic intervals throughout the day the calibration of the instrument should be check and re-evaluated.
- Apply the calibration gas and proceed as directed in the operator's manual.
- After calibration is complete, record the final calibrated reading on the field equipment calibration forms and in the field logbook. At periodic intervals throughout the day the calibration of the instrument should be check and re-evaluated.

<u>Groundwater Parameter Instruments</u> (pH, Temperature, Electrical Conductivity, Turbidity, etc.)

Frequently one instrument will have multiple sensors for measuring various parameters in water. Sensors for temperature, electrical conductivity and turbidity require scheduled calibrations by the equipment manufacturer or authorized service center and should not be performed in the field. The sensor for pH analysis should be calibrated daily in the field prior to use.

- Turn the instrument on. The on/off switch may be a toggle switch, knob, or button to be depressed depending on the type and brand of instrument being used.
- Allow the instrument to "warm up" and progress through the startup diagnostic routine.
- Apply pH 7 and pH 4 buffers solutions as instructed by the instrument prompts or the operator's manual.
- Adjust the reading of the instrument to correlate to the corresponding buffer solution being applied.
- Record reading in the field logbook and on proper field calibration forms.
- Dispose of used buffer solution and reseal buffer solution containers for future use.

<u>Water Level Indicator and Petroleum/Water Interface Probe</u>

Field calibration of this instrument is not required. Rather a series of field checks to ensure the instrument is in proper working order will be described.

- Turn the instrument on. The on/off switch is usually a knob located on the side of the reel in which the measuring tape is rolled onto.

- Push the "test" button to ensure that the batteries are in working order. If the batteries are working, an audible tone will be heard and a visible light located on the side of the real will illuminate.

- Immerse the sensor probe in potable water to ensure the audible tone is heard and visible light illuminates when the electrical circuit is completed when the probe enters the water. Make an observation of where the water level is at on the probe when the circuit is completed. Repeat this step several times to familiarize yourself with this contact point. By performing this step, the chance of submersing the probe to a greater depth than necessary is reduced. Over submersion of the probe will result in a greater amount of the probe and measuring tape to be cleaned and decontaminated prior to collection of another groundwater measurement.

- After collection of every water level measurement, decontaminate all portions of the water level meter or petroleum/water interface probe that came in contact with the groundwater as outlined in SOP No. 4 – Decontamination.

6. Decontamination

Small instruments and equipment will be cleaned according to SOP No. 4 – Decontamination and the generalized procedures stated below:

a. Rinse with potable water to remove the gross contamination

b. Scrub with brush using Alconox soap (or equivalent) and distilled water solution

c. Rinse with distilled water.

Decontaminated equipment should be wrapped in aluminum foil or placed in plastic bags between uses and during storage.

1. Summary

The purpose of this Standard Operating Procedure (SOP) is to define the procedures and necessary equipment for installation of groundwater monitoring wells and piezometers. A piezometer is simply a small diameter monitoring well. Therefore, the equipment and procedures for building a piezometer are the same as those used to install any monitoring well. The step-by-step procedures described herein are sufficiently detailed to allow field personnel to properly install any size monitoring well. Other related SOPs are listed below:

- SOP No. 4 – Decontamination
- SOP No. 8 – Field Reporting and Documentation
- SOP No. 17 – Logging
- SOP No. 28 – Soil Sampling

2. Equipment

This section details the required equipment for the drilling and installation of groundwater monitoring wells.

The following is an equipment list typical for well drilling and installation:

- Drill rig capable of installing wells to the desired depth in the expected formation materials and conditions
- Well casing and well screen
- Bentonite pellets or chips
- Filter pack sand
- Portland Type I or II Cement and powdered bentonite for grouting
- Protective well casing with locking cap
- High-pressure steamer/cleaner
- Long-handled bristle brushes
- Wash/rinse tubs
- Appropriate decontamination supplies as specified in SOP No. 4 - Decontamination
- Location map
- Plastic bags (Ziploc)

- Self-adhesive labels
- Weighted tape measure
- Water level probe
- Deionized or distilled water
- Appropriate health and safety equipment as specified in the Health and Safety Plan (HSP)
- Log book
- Boring log sheets
- Well construction form
- Plastic sheeting
- Drums for containment of cuttings and Decontamination and/or development water (if necessary).

3. Procedures

Decontamination

Before drilling or well installation begins, all drilling and well installation material will be decontaminated according to the protocols listed in SOP No. 4 - Decontamination. Drilling equipment will be decontaminated between well locations.

Instrument Calibration

Before going into the field, the sampler shall verify that field instruments are operating properly. Calibration times and readings will be recorded in a notebook to be kept by the field sampler. Specific instructions for calibrating the instruments are given in the respective SOPs.

Drilling and Well Installation Procedures

Drilling Technique

If soil sampling is required, all soil samples will be taken following the protocol outlined in SOP No. 28 - Soil Sampling. The hole will be logged following the methods specified in SOP No. 17 – Logging.

Boreholes will be advanced using drilling methods specified in the Work Plan and a drill rig capable of completing the monitor well(s) to the depth(s) specified in the Scope of Work. Before drilling, well locations will be numbered and staked. The necessary permits and utility clearances will be obtained prior to commencement of drilling activities. Appropriate health and safety measures will be followed during drilling and well installation activities as specified in the Health and Safety Plan.

During the drilling operation, the cuttings from the boring will be containerized or placed directly onto the ground as specified in the Work Plan. Disposal of cuttings will be in accordance with the Work Plan.

Monitor Well Drilling Operations

The procedures for drilling are as follows:

- Set up drilling rig at staked and cleared borehole location.
- Record location, date, time and other pertinent information in the field book.
- Drill hole of appropriate size using hollow-stem augers.
- Collect samples at the predetermined intervals, if appropriate, for sample description and/or chemical analysis as specified in the Work Plan. See SOP No. 17 - Logging for instruction.
- Complete the borehole to the depth specified in the Work Plan.

Well Design Specifications

The following general specifications will be:

Boring Diameter: The boring will be of sufficient diameter to permit at least two inches of annular space between the boring wall and all sides of the centered riser and screen. The boring diameter will be of sufficient size to allow for the accurate placement of the screen, riser, filter pack, seal, and grout.

Well Casing: Well riser will consist of new threaded, flush joint, PVC or stainless steel. Well diameter and thickness will be specified in the Work Plan. Risers will extend approximately two feet above the ground surface, except in the case of flush-mount surface casings (see Work Plan for appropriate construction). The tops of all well casings will be fitted with expandable locking caps or PVC slip caps.

Well Screens: Screen length for each well will be specified in the Work Plan. Well screens will consist of new threaded pipe with factory-machine slots/ wrapped screen with an inside diameter equal to or greater than that of the well casing. The slot size will be indicated in the Work Plan and designed to be compatible with aquifer and sand pack material. The schedule thickness of PVC screen will be the same as that of the well casing. All screen bottoms will be fitted with a cap or plug of the same composition as the screen and should be within 0.5 foot from the open part of the screen. Traps may be used.

Well Installation Procedure

The following procedures will be initiated within 12 consecutive hours of boring completion for uncased holes or partially cased holes and within 48 consecutive hours for fully cased holes. Once installation has begun, no breaks in the installation procedure will be made if no unusual conditions are encountered until the well has been grouted and the drill casing has been removed.

The procedure for monitoring well installation is as follows:

1. Decontaminate all well materials according to SOP No. 4 - Decontamination. Following decontamination, all personnel that handle the casing will don a clean pair of rubber or surgical gloves.
2. Measure each section of casing, and screen, to nearest 0.10 foot.
3. Assemble screen and casing as it is lowered into the borehole.
4. Lower screen and casing to about 6 inches above the bottom of the boring.
5. Record the level of top of casing and calculate the screened interval. Adjust screen interval by raising assembly to desired interval if necessary and add sand to raise the bottom of the boring.
6. Calculate and record the volume of the filter pack, bentonite seal, and grout required for existing boring conditions.
7. Begin adding filter pack sand around the annulus of the casing a few feet at a time. Repeated depth soundings shall be taken to monitor the level of the sand.
8. Allow sufficient time for the filter sand to settle through the water column outside the casing before measuring the sand level.
9. Extend the filter pack sand to at least 2 feet above the top of the well screen.
10. Following sand filter pack placement in the shallow wells, install a minimum 3 foot-thick seal of bentonite pellets or chips by slowly adding the pellets to avoid bridging. The thickness of the completed bentonite seal shall be measured before the pellets are allowed to swell. The completed bentonite seal shall be allowed to hydrate before proceeding with the grouting operations.
11. Grout the remaining annulus from the top of the bentonite seal to about 3 feet below the surface as measured after the augers are removed. The grout will be tremied into the borehole until the annulus is completely filled. The base of the tremie pipe should be placed approximately 5 feet above the bentonite seal.

12. After the grout sets for 24 hours it will be checked for settlement. If necessary, additional grout will be added to top off the annulus.

13. The concrete pad and bollards, if required, will be installed according to specifications in this SOP. The protective casing and posts will be painted a high visibility color.

14. Optional - URS personnel will affix a permanent, non-corrosive tag to the outer steel protective casing of each well which clearly identifies the well number.

Well Installation Specifications:

Filter Pack: The annular space around the well screen will be backfilled with a clean, washed, silica sand sized to perform as a filter between the formation material and the well screen. The filter pack will extend a minimum two feet above the screen and may be tremied into place. The final depth to the top of the filter pack will be measured directly using a weighted tape measure or rod and not by using volumetric calculation methods. The grain size of the filter pack will be shown on the well construction log.

Bentonite Seal and Grout: A two-foot thick bentonite pellet/slurry seal will be placed in the annulus above the filter pack. The thickness of the seal may vary slightly based on site conditions. The thickness of the seal will be measured immediately after placement, without allowance for swelling. Bentonite slurry seals should have a thick batter-like consistency. Slurry seals will have a maximum placement thickness of 8 feet. Cement grout will then be placed from the top of the bentonite seal to the ground surface. The cement grout will consist of a mixture of Portland cement (ASTM C150) and clean water in the proportion of not more than seven gallons of clean water per bag of cement (one cubic foot or 94 pounds). Additionally, three percent by weight of bentonite powder will be added if permitted by state regulations. The grout will be prepared in an above-ground rigid container by first thoroughly mixing the cement with water and then mixing in the bentonite powder. The grout will be placed by pumping through a tremie pipe. The lower end of the tremie pipe will be kept within five feet of the top of the bentonite seal. Grout will be pumped through the tremie pipe until undiluted grout flows from the annular space at the ground surface. The tremie pipe will then be removed and more grout added to compensate for settling. After 24 hours, the drilling contractor will check the site for grout settlement and add more grout to fill any depression. This will be repeated until firm grout remains at the surface.

Protection of Well: URS personnel will at all times during the progress of the work, take precautions to prevent tampering with the wells or entrance of foreign material into them. Upon completion of a well, a suitable cap will be installed to prevent foreign material from entering the well. The wells will be enclosed in a steel protective casing. Steel casings will be, at a minimum, 4 inches in diameter and will be provided with locking caps and locks. All locks will be keyed alike. If the well is to be a stickup, as specified in the Work Plan, a 1/4-inch drainage hole will be drilled in the protective steel casing centered approximately 1/8-inch above the internal mortar collar for drainage. The well designation will be painted on the protective casing, using a brush. Painting will be done prior to well development. If specified in the Work Plan, a minimum 2-foot by 2-foot, 6 to 8-inch-thick concrete pad, sloped away from the well, will be constructed around the protective casing at the final ground level elevation. Three or four 2-inch-diameter or larger steel posts will be equally spaced around the well and embedded in separate concrete filled holes just outside of the concrete pad. The protective steel posts will extend approximately 1 foot above the well riser. Any well that is to be temporarily removed from service or left incomplete due to delay in construction, will be capped with a water tight cap and equipped with a "vandal-proof" cover satisfying applicable state or local regulations or recommendations.

4. Documentation

Observations and data acquired in the field during drilling and installation of wells will be recorded to provide a permanent record. A boring log will be completed for each boring according to the procedures outlined in SOP No. 17 – Logging..

Additional documentation for well construction will be written in the field book according to SOP No. 8 – Field Reporting and Documentation and will include the following:

- Date
- Time
- Personnel
- Weather
- Subcontractors
- Health and Safety monitoring equipment and readings
- Grout, sand, and bentonite volume calculations prior to well installation
- The quantity and composition of the grout, seals, and filter pack actually used during construction
- Screen slot size (in inches), slot configuration, outside diameter, nominal inside diameter, schedule/thickness, composition, and manufacturer

- Coupling/joint design and composition
- Protective casing composition and nominal inside diameter
- Start and completion dates
- Discussion of all procedures and any problems encountered during drilling and well construction.

In addition, the well installation details will be shown in a diagram which will be drawn in the field book. Each well diagram will consist of the following (denoted in order of decreasing depth from ground surface):

- Reference elevation for all depth measurements
- Project and site names
- Well number
- Date(s) of installation
- The depth at which the hole diameter changes (if appropriate)
- The depth of the static water level and date of measurement(s)
- Total depth of completed well
- Depth of any grouting or sealing
- Nominal hole diameter(s)
- Amount of cement used for grouting or sealing
- Depth and type of well casing
- Description (to include length, internal, diameter, slot size, and material of well screen(s)
- Any sealing off of water-bearing strata
- Static water level upon completion of the well and after development

- Drilling date(s)
- Other construction details of monitoring well including grain size of well filter pack material and location of all seals and casing joints.

1. Well Development

The objective of groundwater monitoring well development is to clear the well of accumulated sediments, when 10% or more of the well screen has been occluded by sediment, so that representative groundwater samples may be collected. The accumulated sediments need to be re-suspended in the water column in order to be removed. A variety of techniques can be used to re-suspend the sediments. Some of the common methods that can be used to re-suspend sediments include using a surge block, injection of air into the water column of the well, or using a bailer. Once the sediment is re-suspended, the water and sediment can then be removed from the well using a submersible pump, an air bladder pump, or a bailer. Development will be considered to be complete when the fine-grained materials have been removed.

The preferred method for development will be surging and removing water with dedicated, disposable, polyethylene bailers or a submersible pump. The following procedures will be used when developing an existing well.

1. Place a clean, plastic drop cloth on the ground around the well to be developed.
2. Unlock the protective well cover and remove the well cap.
3. Check the well for NAPL using an interface probe, as outlined in the water level measurement section below.
4. Measure the depth to groundwater and/or NAPL to the nearest hundredth of a foot.
5. Measure the total depth of the well to the nearest hundredth of a foot. Note whether the bottom of the well feels hard or soft.
6. Attach the decontaminated surge block to the appropriate lengths of pole section and push the surge block to the bottom of the well, or send a bailer to the bottom of the well.
7. Pull and push the surge block/bailer up and down to agitate the water and suspend the sediments in the well.
8. Once sufficient re-suspension has occurred, pull the surge block/bailer out of the well.
9. Attach an appropriate length of polyethylene tubing to a submersible pump, and lower the pump to near the bottom of the well, out of sediment that may be remaining in the bottom of the well.
10. Place the discharge end of the tubing such that purged water will be collected in a 55-gallon drum.

11. Turn on the pump and adjust the flow rate to pump at a sufficiently high rate to allow the sediments to be removed without causing the pump to clog.
12. Continue pumping until relatively sediment-free water is obtained.
13. Remove the pump and allow the well to recover for half an hour. Re-measure the total well depth. If the measured depth indicates 10% or more occlusion, repeat steps 8 through 14. If the measured depth indicates less than 10% well screen occlusion, disconnect the tubing from the pump and place into the appropriate waste container. Dismantle the surge block and pole connectors for decontamination. Pick up and appropriately dispose of plastic sheeting and other disposables into the appropriate waste container. Close and properly label the 55-gallon drum(s).
14. Decontaminate the pump, wiring, and any other equipment, using the steam cleaner.

Note in the field log book the approximate number of gallons of water removed during development of each well.

2. Well Purging

Prior to initiating the well purging process, the following information will be recorded in a field notebook and on the groundwater sampling logs.

- Well number
- Day, date, and time
- Weather conditions
- Condition of the well and surrounding area
- Sampling team members
- Instrument calibration information
- Water level prior to purging
- Depth to the bottom of the well
- Volume of water to be purged
- Physical properties of evacuated water: color, odor, turbidity, presence of non-aqueous phase liquids
- Deviations from planned sampling methodology

- Ambient air monitoring readings.

Low-flow purging techniques will be used to purge the well in accordance with RCRA Groundwater Monitoring TEGD guidelines. These guidelines state that purging will be conducted by removing a minimum of three well volumes of fluid. A well volume of water is calculated using the following formula: $V = \pi r^2 h(7.48)$ where

V = Standing water volume in gallons to be purged

r^2 = Inside radius of well in feet, squared

h = Linear feet of standing water in the casing

One well volume will be calculated so field personnel know when to perform field measurements. Such measurements are performed after the removal of each well volume.

In groundwater systems, naturally occurring metals tend to adsorb to the surfaces of solids. The level of adsorbance depends on the pH of the soil and water. The concentration of metals in dissolved form, therefore, is limited by this adsorption and by the metals' low solubilities. Sediment in water is likely to have metal ions adsorbed to its particles, which analytical methods may not be able to differentiate from metal ions dissolved in the water. Groundwater samples that contain sediment, therefore, may yield analytical results that do not represent the concentration of metals in the groundwater itself.

Moreover, the transport of sediment is generally not due to the natural flow of groundwater, but is induced by the sampling. Samples that are collected for metals analysis should exhibit low turbidity, and they are generally filtered to remove sediment. When possible, low turbidity samples should be obtained without filtering. A turbidity meter will be used to monitor turbidity during sampling. Following the extraction of each well volume, turbidity will be monitored in the field. Additionally, pH, conductivity, and temperature will be measured and recorded after each well volume removed. Purging is deemed complete when these parameters have stabilized within 10% over a minimum of two successive well volumes. Samples will be collected when turbidity levels are below 5 nephelometric turbidity units (NTU). Should a turbidity level of 5 NTU be unachievable after 2 hours of purging, the samples will be collected and the turbidity recorded.

The procedures for well purging are described as follows:

- The low-flow pump will be lowered into the well, and the pump intake will be located at the approximate midpoint of the screened interval. Once the pump is in place, the controller will be set for the desired flow rate. The optimum flow rate is dependent on the site-specific hydrogeology and will be determined in the field, however, the flow rate will not exceed 1 L/min.

- Pump the groundwater into a graduated pail. Continue pumping until the turbidity reading is at or below 5 NTU unless that is unattainable then the turbidity reading is within 10% for two consecutive well volumes, the well is pumped dry.
- If the well is purged dry, allow sufficient time for the well to recover before proceeding. Record this information on the groundwater sampling log.
- In addition to the turbidity readings, in wells which exhibit sufficient recharge, also collect pH, conductivity, and temperature measurements. A minimum of two consecutive measurements should be within the following criteria:
  - ± 0.2 units for pH
  - ± 10% for specific conductivity
  - ± 1 C^{o} for temperature

  Record this information on the groundwater sampling log.

Discharge the water removed during purging or possible decontamination procedures into 55-gallon drums for disposal.

1. Objective

This document defines the standard procedure for measuring water levels in wells. This SOP serves as a supplement to the Work Plan Addendum and Sampling and Analysis Plan Addendum and is intended to be used together with other SOPs. Other related SOPs are listed below:

- SOP No. 4 – Decontamination
- SOP No. 8 – Field Reporting and Documentation
- SOP No. 11 – Groundwater Sampling

2. Equipment

The following equipment is required:

- Water Level probe with 0.01-foot increments;
- Well keys;
- Organic Vapor Analyzer;
- Latex/Nitrile gloves;
- Site logbook;
- Field data sheets;
- Spray Bottle
- Distilled/deionized water;
- Appropriate health and safety equipment;
- Permanent ink pen; and
- Decontamination equipment.

3. Groundwater Level Measurement Procedures

This section provides step-by-step procedures for collecting groundwater monitoring well fluid level measurements. Observations made during the fluid level measurement should be recorded in the field notebook in accordance with the procedures defined in SOP No. 8 on field reporting and documentation.

Appropriate health and safety equipment, as described in the HSP should be worn during well opening, water level measurement, and decontamination. The following procedures will be completed when measuring water levels:

- The water level probe shall be decontaminated prior to use in each monitoring well. Decontamination procedures are discussed in SOP No. 4.
- The well will be approached from upwind, the well cap unlocked and removed, and the air quality monitored in the casing and breathing zone with an FID or PID. Air quality measurements will be recorded in the field notebook.
- Observations regarding the condition of the well, including the well pad, and surface or protective casing, will be documented in the field notebook.
- Put on a new, unused pair of disposable latex or nitrile gloves.
- An electric water level or NAPL interface probe will be used to measure the depth to water from the top-of-casing reference point (either PVC or steel monitoring well casing) and/or check for NAPLs in the water column, where applicable. Record the depth of water and/or NAPLs, as applicable. This procedure will also be used to measure the depth of the well. Measurements will be made to the nearest 0.01 feet.
- The static water level, the total depth of the well, and the depth of NAPL (if applicable), shall be measured with the probe, recorded on the water level data sheet, and then immediately rechecked before the probe is removed from the well.
- All columns of field data sheets shall be completed, including time of measurement. An example water level data sheet is attached to this SOP. If measurements are taken over a several-day period, the date of each measurement should be clearly indicated on the form.
- Care shall be taken to verify the readings during each water level measurement period. Any significant changes in water level will be noted by comparing the most recent measurement with past measurements.
- After any measurement is taken, the water level probe shall be decontaminated as described in SOP No. 4.
- Place disposable equipment into a plastic garbage bag for disposal.

4. Documentation

The water level data sheet attached to this SOP shall be completed during each measuring event. Field data sheets will include field personnel, date, time, well number, total well depth, water level, static water elevation, and comments. A field notebook will also be kept during water level measurement activities describing decontamination procedures, calibration procedures, monitoring procedures, and other observations during water level measurement. Both the data sheets and notebook shall be filled out using legible handwriting, and shall be signed and dated by the person completing the page.

The measured depth to water, in feet below the measuring point, will be subtracted from the measuring point elevation to determine the elevation of the static water level. The resulting elevation shall be checked in the field to see that it is reasonable and that the subtraction was performed correctly. If there is a discrepancy, the water level shall be measured again.

1. Objective

This document defines the standard operating procedure (SOP) and necessary equipment for collection of groundwater samples in monitoring wells, extraction wells, or piezometers using low-flow techniques. The term "Low Flow" refers to the velocity that the groundwater is removed from the soil formation immediately adjacent to the well screen.

In this technique, in order to withdraw water from within the well screen and to lessen drawdown, a pump that minimizes disturbance to the groundwater is operated at a low flow rate. The well is only purged within the screened interval until specific parameters have stabilized and as according to the site-specific work plan. Therefore, the groundwater samples collected are representative of the water bearing formation and hydraulically isolated from the water in the casing. The need to purge three well volumes, as required in traditional techniques, is not necessary with low flow purging and sampling. The low flow procedure described in this SOP is not necessarily applicable for every site or for wells screened in materials with very low permeability.

SOPs providing additional related guidance are listed below:

- SOP No. 4 – Decontamination
- SOP No. 8 – Field Reporting and Documentation.
- SOP No. 10 – Groundwater Level Measurements
- SOP No. 20 – Monitoring Well Development and Purging
- SOP No. 24 – Sample Classification, Packaging and Shipping
- SOP No. 25 – Sample Containers, Preservation, and Holding Times
- SOP No. 26 – Sample Control and Custody Procedures.

2. Equipment

Equipment potentially used during well purging and sampling:

- Well installation forms and boring logs for well being sampled
- Well keys
- Disposable latex or nitrile gloves
- Assorted tools (knife, screwdriver, etc.)
- New synthetic rope

- Pump and required accessories (described in more detail in following section)
- Electronic water level indicator with 0.01-foot increments
- Graduated cylinder
- Temperature meter
- pH meter (with automatic temperature compensation)
- Conductivity meter
- Turbidity meter
- Dissolved oxygen (DO) meter
- Oxidation reduction potential (ORP) meter
- Flow-through cell
- Calibration fluids
- Paper towels or Kimwipes
- Calculator
- Bound field logbook (logbook)
- Waterproof pen and permanent marker
- Plastic buckets
- 55-gallon drums or truck-mounted tank
- Plastic sheeting
- Appropriate decontamination equipment (see SOP No. 4)
- Cooler with ice
- Sample containers and labels
- Groundwater sampling form
- Chain-of-Custody form
- Appropriate health and safety equipment (e.g., photoionization detector (PID))

3. Sampling Procedure

This section provides the step-by-step procedure for collecting groundwater samples in the field. Observations made during groundwater purging and sampling should be recorded in a logbook in accordance with procedures described in SOP No. 8.

A. Any equipment used in the sampling procedure that could contact groundwater should be properly decontaminated before each use (see SOP No.4).

B. Equipment should be calibrated based on the manufacturers' instructions. The frequency of calibration should be specified in the site-specific Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP) or work plan. According to "Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures" (Unites States Environmental Protection Agency (USEPA), 1996), pH calibration should be performed with at least two buffers that bracket the expected range of values. Dissolved oxygen calibration must be corrected for local barometric pressure readings and elevation.

C. Before well purging begins, the following steps should be performed at each well:

- Inspect the well and surrounding site for security, damage, and evidence of tampering. If damage or tampering is evident, contact the project manager for guidance.
- Place clean plastic sheeting around the well (as necessary)
- Measure ambient volatile organic compounds (VOCs) background levels in the immediate vicinity of the well (i.e., using a PID or a flame ionization detector (FID) per the Health and Safety Plan (HASP).
- Remove the well cap and immediately measure VOCs at the rim of the well and record the readings in the logbook or on the groundwater sampling form. Give the water in the well adequate time to reach equilibrium.

D. After the well has reached equilibrium, the groundwater elevation should be measured to the nearest 1/100-foot. The total well depth and screened interval should be obtained from the well logs. Measuring the total depth prior to sampling should be avoided to prevent resuspension of settled solids in the well casings and to minimize the necessary purge time for turbidity equilibration. The total depth of the well should be confirmed after sampling has been completed. A detailed description of monitoring well gauging activities is provided in SOP No. 10.

E. Following measurement of the static groundwater elevation, the appropriate equipment will be slowly and carefully placed in the well. If the wells have light or dense non-aqueous-phase liquids (LNAPLs or DNAPLs) care should be taken to place sampling equipment below or above the NAPL.

Selection of the proper pump is important for low-flow sampling activities. USEPA guidance (1996) notes that dedicated sampling devices capable of purging and sampling are preferred over any other type of device. In addition, the pump must be capable of flow rates between 0.1 and 1.0 liter per minute. A variety of portable sampling devices are available, such as bladder pumps, peristaltic pumps, electrical submersible pumps, gas-driven pumps, inertial lift foot-valve samplers (e.g. check-ball systems), and bailers (a list of pump manufacturers and suppliers is included on pg. 8). However, some of this sampling equipment has drawbacks or has been specifically rejected for low-flow sampling. The peristaltic pump can only be used for shallow applications and it can cause degassing of groundwater. Degassing results in the alteration of pH and alkalinity values as well as some loss of volatiles. Also, USEPA guidance asserts that inertial lift foot-valve type samplers and bailers cause too much groundwater disturbance and may invite unacceptable operator variability. Therefore, these sampling devices should be avoided for low-flow sampling activities.

When placing the equipment in the well, the pump intake should be set near the middle or slightly above the middle of the screened interval. If the screen length allows, the pump intake should be at least two feet from the bottom of the screen. Placing the pump intake near the top of the water column can cause stagnant water from the casing to be purged, but placing the pump intake near to the bottom of the well can cause mobilization and entrainment of settled solids from the bottom of the well.

F. Tubing should be connected from the pump to a flow-through cell. Then, calculate the volume of water to fill the flow-through cell. According to American Society for Testing and Materials (ASTM) Standard D 6771 (2002), the frequency of measurements should be equal to the time required to completely evacuate one volume of the cell. This ensures that independent measurements are made.

G. The pump should be started at a low flow rate, approximately 100 mL/min or the lowest flow rate possible.

H. Water level measurements should continue every two minutes until the measurements indicate that significant drawdown is not occurring. According to ASTM standards (2002), allowable drawdown should never exceed the distance between the top of the well screen and the pump intake. Including a safety factor, also provided by ASTM, drawdown should actually not exceed 25% of this distance. This ensures that water stored in the casing is not purged or sampled. For example, for a 4-foot screen, the pump should be placed at the midpoint of the screen (two feet from the top of the screen to the pump intake). With a safety factor of 25%, this would require drawdown not to exceed six inches.

Once it has been established that significant drawdown is not occurring, the flow rate may be increased to </= 1 L/m (ASTM, 2002) or, if the flow rate remains the same, water level measurements need only to be taken periodically. However, when the flow rate is increased, water level measurements must continue every two minutes.

If drawdown surpasses 25% of the distance from the pump intake to the top of the screen even while pumping is occurring at the lowest flow rate possible, samplers should refer to the project specific criteria as found in the appropriate FSP or work plan.

I. Parameters should be documented on the groundwater sampling form and in the logbook. The time between parameter measurements is calculated as follows:

$$T = \frac{V}{Q}$$, where

T = time between measurements (minutes)

V = volume of the flow-through cell (liters)

Q = purge flow rate (liters per minute)

J. Sampling should as stated in the FSP or work plan. However, in most cases, purging will continue until specific parameters have stabilized over three consecutive flow-through cell volumes. **Table 1** provides guidelines that may be used for parameter stabilization as specified by USEPA, ASTM, and in the Nielsen and Nielsen Technical Guidance on Low-Flow Purging and Sampling and Minimum-Purge Sampling (Nielsen and Nielsen, 2002). These guidelines are to be used in combination with professional judgment.

Table 1. Stabilization Guidelines for Low-Flow Sampling

Parameter	Stabilization Guidelines		
	EPA	ASTM	Nielsen & Nielsen
DO	+/- 10%	+/- 10% or +/-0.2 mg/L, whichever is greatest	+/- 10% or +/-0.2 mg/L, whichever is greatest
ORP	+/- 10 mV	+/- 20 mV	+/- 20 mV
PH	+/- 0.1 units	+/- 0.2 units	+/- 0.2 units
Conductivity	+/- 3%	+/- 3%	+/- 3%
Temperature	Not Specified	Not Specified	+/- 0.2 ºC
Turbidity	+/- 10%	Not Specified	Not Specified

K. After the relevant parameters have stabilized, the flow-through cell should be disconnected or bypassed for sampling. If, after a considerable number of readings have been taken, parameters have not stabilized, samplers should refer to the work plan or possibly use alternative sampling methods.

L. The flow rate should be adjusted to less than 0.5 L/min for sampling to minimize aeration during the sampling of volatiles.

M. A new pair of disposable latex or nitrile gloves should be put on immediately before sampling.

N. The constituents should be sampled for in the order given below:

- VOCs – Vials should be filled completely so that the water forms a convex meniscus then capped so that no air space exists in the vial. Turn the vial over and tap it to check for bubbles. If air bubbles are observed in the sample vial, remove the lid and attempt to fill the vial two more times, (being careful not to dump out any groundwater currently in the vial). If air bubbles are present twice more, discard the sample vial and repeat the procedure with a new vial. If, after three attempts, air bubbles are still in the vial, make a note of this and place the vial in the cooler.

- Gas sensitive parameters (e.g., ferrous iron, methane, alkalinity)
- Semivolatile organic compounds, pesticides, polychlorinated biphenyls, and herbicides
- Petroleum hydrocarbons
- Metals (unfiltered)
- Explosives
- Any filtered analytes (use in-line filters if possible)

O. Place all samples on ice inside a cooler immediately.

P. Each sample should be identified with the Sample ID, location, analysis number, preservatives, date and time of sampling event, and sampler.

Q. The sample time and constituents to be analyzed for should be recorded in the logbook and on the groundwater sampling form.

R. Chain-of-custody procedures should be started.

S. Sample equipment should be decontaminated.

T. The well sampling order should be dependent on expected levels of contamination in each well, if known, and should be determined prior to sampling. Sampling should progress from the least contaminated to the most contaminated well. Quality assurance/quality control (QA/QC) samples should be collected during groundwater sampling as required in the work plan and/or QAPP.

4. List Of Potential Suppliers Who Provide Pumps Suitable for Low-Flow Sampling:

Field Environmental. 1-800-3930-4009. www.fieldenvironmental.com. Pumps: peristaltic, QED bladder pumps, Fultz rotor pump, control boxes, compressors, etc.

QED. 1-800-624-2026. www.micropurge.com. Pumps: bladder pumps, flow cell, compressors, etc.

Fultz Pumps. 1-717-248-2300. www.fultzpumps.com.

5. References

ASTM 2002, Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations, ASTM D6771-02, American Society for Testing and Materials. West Conshohocken, PA.

Nielsen, David and Nielsen, Gillian. Technical Guidance on Low-Flow Purging and Sampling and Minimum-Purge Sampling. Second Edition. NEFS-TG001-02. April 2002.

USEPA. 1996. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. EPA/540/S-95/504. OSWER, April 1996.

1. *Objective*

This document defines the standard Quality Assurance/Quality Control (QA/QC) samples. QA/QC samples are collected during field studies for various purposes which include the isolation of site effects (control samples), define background conditions (background sample), and evaluate field/laboratory variability (spikes and blanks, trip blanks, duplicate, split samples). This SOP is intended to be used together with several other SOPs. Applicable SOPs are listed below:

- SOP No. 6 - EnCore™ Sampling
- SOP No. 8 - Field Reporting and Documentation
- SOP No. 11 - Groundwater Sampling
- SOP No. 18 - Low Flow Groundwater Purging and Sampling
- SOP No. 24 - Sample Classification, Packaging, and Shipping
- SOP No. 25 - Sample Containers, Preservation, and Holding Times
- SOP No. 26 - Sample Control and Custody Procedures
- SOP No. 28 - Soil Sampling
- SOP No. 31 - Surface Water Sampling
- SOP No. 32 – Sediment Sampling.

2. *Equipment*

The following equipment typically is required for this SOP:

- Waterproof coolers (hard plastic or metal)
- Custody Seals
- Field forms such as COC or sample collection sheet
- Field Notebook
- Ice
- Bubble Wrap
- Clear Tape
- Duct Tape

- Zip Loc Bags
- Sample Containers
- Waterproof Pen
- Permanent Marker.

3. QA/QC Samples

- Background Sample – a sample (usually a grab sample) collected from an area, water body, or site similar to the one being studied, but located in an area known or thought to be free from pollutants of concern.

- Split Sample – A sample, which has been portioned into two or more containers from a single sample container or sample mixing container. The primary purpose of a split sample is to measure sample handling variability. A split sample will also measure inter- or intra-laboratory precision.

- Duplicate Sample – Two or more samples collected and representative of a given population. The purpose of a duplicate sample is to estimate the variability of a given characteristic or contaminant associated with a population.

- Trip Blanks – A sample, which is prepared prior to the sampling event in the actual container and is stored with the investigative samples throughout the sampling event. They are then packaged for shipment with the other samples and submitted for analysis. At no time after their preparation are trip blanks to be opened before they reach the laboratory. Trip blanks are used to determine if samples were contaminated during storage and/or transportation back to the laboratory (a measure of sample handling variability resulting in positive bias in contaminant concentration). If samples are to be shipped, trip blanks are to be provided with each shipment but not for each cooler.

- Spikes (also known as proficiency test (pt) samples) – A sample with known concentrations of contaminants. Spike samples are often packaged for shipment with other samples and sent for analysis. At no time after their preparation are the sample containers to be opened before they reach the laboratory. Spiked samples are normally sent with each shipment to contract laboratories only. Spiked samples are used to measure bias due to sample handling or analytical procedures.

- Equipment Field Blanks – a sample collected using organic-free water which has been run over/through sample collection equipment. These samples are used to determine if contaminants have been introduced by contact of the sample medium with sampling equipment. Equipment field blanks are often associated with collecting rinse blanks of equipment that has been field cleaned.

- Temperature Blanks – A container of water shipped with each cooler of samples requiring preservation by cooling to 4^{o}C (ice). The temperatures of the blanks are measured at the time of sample receipt by the laboratory. No temperature blank is necessary for samples designated as "waste".

- Preservative Blanks – A sample that is prepared in the field and used to determine if the preservative used during field operations was contaminated, thereby causing a positive bias in the contaminant concentration. On studies of short duration, usually only a post-preservative blank is prepared at the end of all sampling activities. On studies extending beyond one week, a pre-preservative blank should also be prepared prior to beginning sampling activities. At the discretion of the project leader, additional preservative blanks can be prepared at intervals throughout the field investigation. These blanks are prepared by putting organic/analyte-free water in the container and then preserving the sample with the appropriate chemical.

- Field Blanks – A sample that is prepared in the field to evaluate the potential for contamination of a sample by site contaminants from a source not associated with the sample collected (for example air-borne dust or organic vapors which could contaminate a soil sample). Organic-free water is taken to the field in sealed containers or generated on-site. The water is poured into the appropriate sample containers at pre-designated locations at the site. Field blanks should be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled.

- Material Blanks – Samples of sampling materials (e.g., material used to collect wipe samples, etc.), construction materials (e.g., well construction materials), or reagents (e.g., organic/analyte free water generated in the field, water from local water supplies used to mix well grout, etc.) collected to measure any positive bias from sample handling variability. Commonly collected material blanks are listed below:

- Wipe Sample Blanks – A sample of the material used for collecting wipe samples. The material is handled, packaged, and transported in the same manner as all other wipe samples with the exception that it is not exposed to actual contact with the sample medium.
- Grout Blanks – a sample of the material used to make seals around the annular space in monitoring wells. Filter Pack Blanks -- a sample of the material used to create an interface around the screened interval of a monitoring well.
- Construction Water Blanks – a sample of the water used to mix or hydrate construction materials such as monitoring well grout.
- Organic/Analyte Free Water Blanks – a sample collected from a field organic/analyte free water generating system. The sample is normally collected at the end of sampling activities since the organic/analyte free water system is recharged prior to use on a study. On large studies, samples can be collected at intervals at the discretion of the project leader. The purpose of the organic/analyte free water blank is to measure positive bias from sample handling variability due to possible localized contamination of the organic/analyte free water generating system or contamination introduced to the sample containers during storage at the site. Organic/analyte free water blanks differ from field blanks in that the sample should be collected in as clean an area as possible (a usual location for the organic/analyte free water system) so that only the water generating system/containers are measured.

- Matrix Spike – A matrix spike is a known concentration of a target analyte(s) which is introduced into a second sample aliquot. The spiked sample is processed through the entire analytical procedure. Analysis of the matrix spike is used as an indicator of sample matrix effect on the recovery of target analyte(s).
- Matrix Spike Duplicate – A matrix spike duplicate is a known concentration (same as the matrix spike) of a target analyte(s) which is introduced into a third sample aliquot. The spiked sample is processed through the entire analytical procedure. Analysis of the matrix spike duplicate is used as an indicator of sample matrix effect on the recovery of target analyte(s) as well as method precision.

4. Sample Containers

Certified commercially clean sample containers will be obtained from the contract analytical laboratory. The lab will indicate the type of sample to be collected in each bottle type. The work plan will list the appropriate sample containers for the specific analyses require for each project.

5. Sample Preservation

Samples will be preserved at the time of the sample collection. Chemical preservatives, if necessary, will be added to the sample containers either by the laboratory prior to shipment to the field, or in the field by sampling personnel.

After sample collection, each container will be labeled (see SOP No. 24) and stored on ice at 4°C in an insulated cooler until packed for shipment to the laboratory. The ice will be double bagged in Zip Loc storage bags. Freezing samples will not be permitted. Any breakable sample bottles need to be wrapped in protective packing material (bubble wrap) to prevent breakage during shipping.

6. QA/QC Sample Collection Frequency

QA/QC Sample	**Frequency**
Background Sample	Project Specific
Split Sample	Project Specific
Duplicate Sample	One per 10 samples collected per matrix
Trip Blank	One per cooler containing VOC samples
Spikes	One per 20 samples collected per matrix
Equipment Field Blanks	One per 10 samples collected
Temperature Blanks	One per cooler
Preservative Blanks	One post sampling – for projects less than one week. Two samples (one pre- and one post sampling) – for projects longer than one week.
Field Blanks	One per 20 samples collected per matrix
Material Blanks	One per matrix
Matrix Spike	One per 20 samples collected per matrix
Matrix Spike Duplicate	One per 20 samples collected per matrix

1. Objective

This document defines the standard procedure for the control and custody of environmental samples. This SOP is intended to be used together with several other SOPs. Applicable SOPs are listed below:

- SOP No. 6 - EnCore™ Sampling
- SOP No. 8 - Field Reporting and Documentation
- SOP No. 11 - Groundwater Sampling
- SOP No. 24 - Sample Classification, Packaging, and Shipping
- SOP No. 25 - Sample Containers, Preservation, and Holding Times
- SOP No. 28 - Soil Sampling
- SOP No. 31 - Surface Water Sampling
- SOP No. 32 - Sediment Sampling.

2. Equipment

The following equipment will be needed for sample control and custody procedures:

- Waterproof coolers (hard plastic or metal)
- Custody Seals
- Field forms such as a Chain of Custody (COC) or sample collection sheet
- Field Notebook
- Ice
- Sample Log-in Book
- Clear Tape
- Duct Tape
- Zip-Loc Bags
- Waterproof pens
- Permanent Markers.

3. Sample Control and Custody Procedures

Once the samples are collected, they must remain in the custody of the sampler or another worker from the site. The samples can also remain unattended in a locked vehicle so tampering with the samples will not be possible. Right before shipment, a custody seal should be placed over the opening of the cooler and then the cooler should be taped all the way around with clear packing tape to prevent tampering with the samples. Samples will be hand delivered or shipped by overnight express carrier for delivery to the analytical laboratory (see SOP No. 24). All samples must be shipped for laboratory receipt and analyses within specific holding times. This may require daily shipment of samples with short holding times. Each cooler will contain a chain of custody (COC) form.

During field sampling activities, traceability of the samples must be maintained from the time the samples are collected until the laboratory data is issued. Initial information concerning the collection of the samples will be recorded in the field log book as outlined in SOP No. 8 – Field Reporting and Documentation. Information on the custody, transfer, handling, and shipping of samples will be recorded on a COC form. An example of a COC is attached to this SOP. The COC is a three-part carbonless form.

The sampler will be responsible for initiating and filling out the COC form. The COC will be signed by the sampler or the field person responsible for sample handling when the sampler relinquishes the samples to anyone else. One COC form will be completed for each cooler of samples collected daily and if samples are not hand delivered, the COC will be placed in a Zip-Loc bag and shipped inside the cooler. COC forms will be used to document the transport and receipt of samples from the field to the lab. Information required on a COC includes the following:

- Samplers signature and affiliation
- Project Number
- Date and time of collection
- Sample identification number
- Sample Type
- Analyses requested.
- The total number of containers being sent to the lab for each sample
- The appropriate preservative used

- If any samples are to be placed on hold at the laboratory, this should be clearly indicated on the COC in the comments section
- Signature of person(s) relinquishing custody, dates, and times
- Signature of person(s) accepting custody, dates, and times
- Method of shipment
- Shipping air bill number (if appropriate).

The person responsible for delivery of the samples to the laboratory will sign the COC form, retain the last copy of the three-part COC form, document the method of shipment, and send the original and the second copy of the COC form with the samples. Upon receipt at the laboratory, the person receiving the samples will sign the COC form. The original COC will remain with the samples until final disposition of the samples by the laboratory. The laboratory will dispose of the samples in an appropriate manner 60 to 90 days after data reporting.

SHEET___of___

CHAIN OF CUSTODY RECORD

URS CORPORATION

1001 HIGHLAND PLAZA DRIVE WEST, SUITE 300
ST. LOUIS, MISSOURI 63110
314-429-0100

PROJECT NO:	PROJECT NAME:		NO. OF CONTAINERS	CONTAINER DESCRIPTION / ANALYSES REQUESTED						REMARKS
SAMPLER'S: (Signature)										
DATE	TIME	SAMPLE I.D. NUMBER								

RELINQUISHED BY: (Signature)	DATE / TIME	RECEIVED BY: (Signature)	DATE / TIME
RELINQUISHED BY: (Signature)	DATE / TIME	RECEIVED AT LAB BY: (Signature)	DATE / TIME
METHOD OF SHIPMENT:		AIRBILL NO:	

1. Purpose and Scope

This document defines the standard protocols for sample handling, documentation, and tracking. This SOP serves as a supplement to the Work Plan Addendum and Sampling and Analysis Plan Addendum and is intended to be used together with several other SOPs. Applicable SOPs are listed below:

- SOP No. 6 - EnCore™ Sampling
- SOP No. 11 - Groundwater Sampling
- SOP No. 25 - Sample Containers, Preservation and Holding Times
- SOP No. 26 - Sample Control and Custody Procedures
- SOP No. 28 – Soil Sampling
- SOP No. 31 - Surface Water Sampling
- SOP No. 32 - Sediment Sampling

2. Procedures For Sample Identification, Handling, And Documentation

2.1 Sample Identification

Samples collected during site activities shall have discrete sample identification numbers. These numbers are necessary to identify and track each of the many samples collected for analysis during the life of project. In addition, the sample identification numbers can be used in a database to identify and retrieve the analytical results received from the laboratory.

Each sample is identified by a unique code which indicates the site identification number, sample location number, sample matrix identifier, and sample depth. The sample locations will be numbered sequentially.

If used, sample matrix identifiers may include the following:

SF - Direct-Push Soil Sample (Field Analysis)

SL - Direct-Push Soil Sample (Laboratory Analysis)

WF - Direct-Push Groundwater Sample (Field Analysis)

SS - Soil Sample

GW - Groundwater (from a Monitoring Well)

SW - Surface Water Sample

SD - Sediment Sample

SL - Sludge or Sewer Sediment Sample

TB - Trip Blank

RN - Rinsate (Deionized Water)

An example of the sample identification number codes for a sewer sediment sample collected for field analysis will be: AUS-0A2B-004-SL-05.

Where AUS indicates Additional Uncharacterized Sites, 0A2B indicates the site location, 004 indicates the sample location, SL indicates the sample media, and 05 indicates the sampling interval.

The sampling locations, sample type, and sample sequence identifiers will be established prior to field activities for each sample to be collected. On-site personnel will obtain assistance from the Project Manager in defining any special sampling requirements.

2.2 Sample Labeling

Sample labels will be filled out as completely as possible by a designated member of the sampling team prior to beginning field sampling activities each day. The date, time, sampler's signature, and the last field of the sample identification number should not be completed until the time of sample collection. All sample labels shall be filled out using waterproof ink. At a minimum, each label shall contain the following information:

- Sampler's company affiliation
- Site location
- Sample identification code
- Date and time of sample collection
- Analyses required
- Method of preservation (if any) used
- Sample matrix (i.e., soil, groundwater, surface water)
- Sampler's signature

2.3 Sample Handling

This section discusses proper sample containers, preservatives, and handling and shipping procedures.

2.3.1 Sample Handling and Shipping

After sample collection, each container will be labeled as described above, and then stored on ice at 4°C in an insulated cooler until packed for shipment to the laboratory. The ice will be double bagged in Ziploc-type storage bags.

The sample containers will be placed in reclosable Ziploc plastic storage bags and wrapped in protective packing material (bubble wrap). Samples will then be placed right side up in a cooler with ice (double bagged using plastic bags), and taped with a custody seal for delivery to the laboratory. Samples will be hand delivered or shipped by overnight express carrier for delivery to the analytical laboratory. All samples must be shipped for laboratory receipt and analyses within specific holding times. This may require daily shipment of samples with short holding times. A chain-of-custody (COC) form will accompany each cooler. The temperature of all coolers will be measured upon receipt at the laboratory. A temperature blank will be included in each cooler for temperature measurement purposes.

2.4 Sample Documentation and Tracking

This section describes documentation required in the field notes and on the sample Chain-of-Custody forms.

2.4.1 Field Notes

Documentation of observations and data acquired in the field will provide information on the acquisition of samples and also provide a permanent record of field activities. The observations and data will be recorded using pens with permanent waterproof ink in a permanently bound weatherproof field log book containing consecutively numbered pages.

The information in the field book will include the following as a minimum. Additional information is included in the specific SOPs regarding the field books.

- Project name
- Location of sample
- Sampler's printed name and signature
- Date and time of sample collection
- Sample identification code including QC and QA identification
- Description of samples (matrix sampled)
- Sample depth (if applicable)

- Number and volume of samples
- Sampling methods or reference to the appropriate SOP
- Sample handling, including filtration and preservation, as appropriate for separate sample aliquots
- Analytes of interest
- Field observations
- Results of any field measurements, such as depth to water, pH, temperature, and conductivity
- Personnel present
- Level of PPE used during sampling.

Changes or deletions in the field book should be lined out with a single strike mark, initialed, and remain legible. Sufficient information should be recorded to allow the sampling event to be reconstructed without relying on the sampler's memory.

Each page in the field books will be signed by the person making the entry at the end of the day, as well as on the bottom of each page. Anyone making entries in another person's field book will sign and date those entries.

2.4.2 Sample Chain-of-Custody

During field sampling activities, traceability of the sample must be maintained from the time the samples are collected until laboratory data are issued. Initial information concerning collection of the samples will be recorded in the field log book as described above. Information on the custody, transfer, handling, and shipping of samples will be recorded on a COC form. The COC is a three-part carbonless form.

The sampler will be responsible for initiating and filling out the COC form. The COC will be signed by the sampler when the sampler relinquishes the samples to anyone else. One COC form will be completed for each cooler of samples collected daily. The COC will contain the following information:

- Sampler's signature and affiliation
- Project number
- Date and time of collection

- Sample identification number
- Sample type
- Analyses requested
- Number of containers
- Signature of persons relinquishing custody, dates, and times
- Signature of persons accepting custody, dates, and times
- Method of shipment
- Shipping air bill number (if appropriate).

The person responsible for delivery of the samples to the laboratory will sign the COC form, retain the last copy of the three-part COC form, document the method of shipment, and send the original and the second copy of the COC form with the samples. Upon receipt at the laboratory, the person receiving the samples will sign the COC form and return the second copy to the Project Manager. Copies of the COC forms documenting custody changes and all custody documentation will be received and kept in the central files. The original COC forms will remain with the samples until final disposition of the samples by the laboratory. The analytical laboratory will dispose of the samples in an appropriate manner 60 to 90 days after data reporting. After sample disposal, a copy of the original COC will be sent to the Project Manager by the analytical laboratory to be incorporated into the central files.

1. Objective

This document defines the standard protocols for sample handling, documentation, and tracking. This SOP is intended to be used together with several other SOPs. Applicable SOPs are listed below:

- SOP No. 6 – EnCore™ Sampling
- SOP No. 8 – Field Reporting and Documentation
- SOP No. 11 – Groundwater Sampling
- SOP No. 18 – Low Flow Groundwater Purging and Sampling
- SOP No. 23 – Quality Assurance Samples
- SOP No. 24 – Sample Classification, Packaging, and Shipping
- SOP No. 26 – Sample Control and Custody Procedures
- SOP No. 28 – Soil Sampling
- SOP No. 31 – Surface Water Sampling
- SOP No. 32 – Sediment Sampling.

2. Equipment

The following equipment will be required for this SOP:

- Waterproof coolers (hard plastic or metal)
- Custody Seals
- Field forms such as COC or sample collection sheet
- Field Notebook
- Ice
- Bubble Wrap
- Clear Tape
- Duct Tape
- Zip Loc Bags
- Sample Containers

- Waterproof Pen
- Permanent Marker.

3. Sample Containers

Certified commercially clean sample containers will be obtained from the contract analytical laboratory. The lab will indicate the type of sample to be collected in each bottle type. The work plan will list the appropriate sample containers for the specific analyses required for each project.

4. Sample Preservation

Samples will be preserved at the time of the sample collection. Chemical preservatives, if necessary, will be added to the sample containers either by the laboratory prior to shipment to the field, or in the field by sampling personnel.

After sample collection, each container will be labeled (see SOP No. 24) and stored on ice at 4°C in an insulated cooler until packed for shipment to the laboratory. The ice will be double bagged in Zip Loc storage bags. Freezing samples will not be permitted. Any breakable sample bottles need to be wrapped in protective packing material (bubble wrap) to prevent breakage during shipping.

5. Sample Hold Times

Samples will be hand delivered or shipped by overnight express carrier for delivery to the analytical laboratory. All samples must be shipped for laboratory receipt and analyses within specific holding times. This may require daily shipment of samples with short holding times. The hold time varies for each type of analysis; therefore, it will be necessary to check with the lab to verify the hold times to determine how frequently samples need to be sent to the lab. Typical hold times are provided in Table 1.

Documentation of observations and data acquired in the field will provide information on the acquisition of samples and also provide a permanent record of field activities. The observations and data will be recorded using pens with permanent waterproof ink in a permanently bound weatherproof field log book containing consecutively numbered pages. Documentation for the sample containers, preservation, and hold times is outlined in SOP No. 8 Field Reporting and Documentation.

Table 1
SOP No. 25
Sample Containers, Preservatives, and Holding Times
Typical Sample Hold Times

Analysis	Holding Time	Preservation
% Lipids	NA	Freeze
Alkalinity	14 days	Cool to 4°C
Ammonia NH3	28 days	Cool to 4°C - H2SO4 to pH<2
Asbestos	1 year	None
BOD 5	48 hours	Cool to 4°C
BOD 5 Inhibited	48 hours	Cool to 4°C
BTEX	14 days	Cool to 4°C; HCl
Chloride	28 days	Cool to 4°C
Chlorophyll	24 hrs to filtration - 28 days after filtration	Freeze filters in 90% acetone
Chromium VI (Hexavalent) in water	24 hours	Cool to 4°C
COD	28 days	Cool to 4°C - H2SO4 to pH<2
Coliform (fecal and total)	6 hours	Cool to 4°C; 0.008% Sodium Thiosulfate
Conductivity	28 days	Cool to 4°C
Cyanide in Soil	14 days	Cool to 4°C
Cyanide in Water	14 days	Cool to 4°C NaOH to pH>12; 0.6 g ascorbic acid
Enterococci	6 hours	Cool to 4°C; 0.008% Sodium Thiosulfate
Fecal Streptococcus	6 hours	Cool to 4°C; 0.008% Sodium Thiosulfate
Fluoride in Soil	28 days	Cool to 4°C
Fluoride in Water	28 days	Cool to 4°C
Grain Size Sediment	6 months	None required
Guaiacols/Catechols/Phenols	30 days	Cool to 4°C; H2SO4 to pH<2
Halogenated Hydrocarbons HH	7 days water/14 days soil	Cool to 4°C
Hardness	6 months	HNO3 to pH<2
Herbicides	7 days water/14 days soil	Cool to 4°C
Hydrocarbon chlorinated	7 days water/14 days soil	Cool to 4°C Ascorbic acid
Ignitability	None	Cool to 4°C

Table 1
SOP No. 25
Sample Containers, Preservatives, and Holding Times
Typical Sample Hold Times

Analysis	Holding Time	Preservation
Iron and sulfur bacteria	6 hours	Cool to 4°C; 0.008% Sodium Thiosulfate
Klebsiella	6 hours	Cool to 4°C; 0.008% Sodium Thiosulfate
Mercury in Water	28 days	Cool to 4°C; HNO3 to pH<2
Metals -- Except Cr(6) and Hg	180 days	HNO3 to pH <2
Metals dissolved	6 months	Filter - then add HNO3 to pH<2
Nitrate NO3-	48 hours	Cool to 4°C
Nitrate-Nitrite	28 days	Cool to 4°C; H2SO4 to pH<2
Nitrite NO2-	48 hours	Cool to 4°C
Nitrogen Pesticides	7 days water/14 days soil	Cool to 4°C
NWTPH-Dx and NWTPH-HCID	7 days water/14 days soil	Cool to 4°C HCl to pH<2
NWTPH-Gx	14/14 days	Cool to 4°C HCl to pH<2
Oil & Grease in Water	28 days	Cool to 4°C; HCl to pH<2
Oil and Grease in Soil	28 days	Cool to 4°C
Organic Screen (PAH Phenolics Creosote etc.)	7 days water/14 days soil	Cool to 4°C
Organophosphorus pesticides	7 days water/14 days soil	Cool to 4°C
Ortho Phosphate PO43-	48 hours	Filter; Cool to 4°C
PAH Hazardous Waste Designation w/o HPLC	7 days water/14 days soil	Cool to 4°C
PAH Polynuclear Aromatic Hydrocarbons	7 days water/14 days soil	Cool to 4°C
PCBs only	7 days water/14 days soil	Cool to 4°C
Percent Solids Soil/Tissue	7 days	Cool to 4°C
Personal Monitors	None	None

Table 1
SOP No. 25
Sample Containers, Preservatives, and Holding Times
Typical Sample Hold Times

Analysis	Holding Time	Preservation
Pesticides/PCBs	7 days water/14 days soil	Cool to 4°C
pH	24 hours	Cool to 4°C
Phenolics in Soil (4AAP)	28 days	Cool to 4°C
Phenolics in Water (4AAP)	28 days	Cool to 4°C; H3PO4; FeSO4 and CuSO4
PM10	1 year	Cool to 4°C
PM2.5	30 days	Cool to 4°C
Resin/Fatty acids	30 days	Cool to 4°C NaOH to pH>10
Semivolatiles BNA	7 days water/14 days soil	Cool to 4°C
Settleable Solids(SS)	48 hours	Cool to 4°C
Specific conductance	28 days	Cool to 4°C
Sulfate	28 days	Cool to 4°C
Sulfide	7 days	Zinc acetate; NaOH to pH>9
TOC in Soil	28 days5	Cool to 4°C
TOC in Water	28 days	Cool to 4°C; H2SO4 to pH<2
Total Dissolved Solids(TDS)	7 days	Cool to 4°C
Total Kjeldahl Nitrogen (TKN)	28 days	Cool to 4°C; H2SO4 to pH<2
Total Non-Volatile Solids(TNVS)	7 days	Cool to 4°C
Total Non-Volatile Suspended Solids(TNVSS)	7 days	Cool to 4°C
Total Persulfate Nitrogen (TPN)	28 days	Cool to 4°C; H2SO4 to pH<2
Total Phosphorus (TP)	28 days	Cool to 4°C; H2SO4 to pH<2
Total Solids(TS)	7 days	Cool to 4°C
Total Suspended (TSS)	7 days	Cool to 4°C
Total Volatile Solids(TVS)	7 days	Cool to 4°C
Tributyl tin	7 days water/14 days soil	Cool to 4°C

Table 1
SOP No. 25
Sample Containers, Preservatives, and Holding Times
Typical Sample Hold Times

Analysis	Holding Time	Preservation
Turbidity	48 hours	Cool to 4°C
VOA Air Toxics	none	Room temperature
Volatile Organics/VOA	7 days water/14 days soil	Cool to 4°C HCl -- ascorbic acid

1. Purpose and Scope

This Standard Operating Procedure (SOP) describes the standard protocols for operating, calibrating, and maintaining equipment commonly used during water quality monitoring. This SOP also defines the documentation necessary when using this equipment.

This SOP serves as a supplement to the Work Plan and is intended to be used together with other SOPs. Other related SOPs are listed below:

- SOP No. 11 – Groundwater Sampling
- SOP No. 18 – Low Flow Groundwater Purging and Sampling
- SOP No. 31– Surface Water Sampling
- SOP No. 42 – Groundwater Profiling.

Health and safety procedures and equipment that will be required during the investigation are detailed in the HSP.

2. Water Quality Monitoring Procedures

2.1 Equipment List

Equipment used for monitoring water quality parameters is as follows:

- Horiba U-10 Water Quality Checker (or similar) – measures pH, temperature, turbidity, dissolved oxygen and conductivity
- Other water quality monitoring devices (if necessary)
- Distilled water
- Dry, clean paper towels
- Latex gloves
- Field log book
- Manufacturer's guide for each meter used
- Calibration fluids

2.2 Calibration Procedure

The following are general calibration procedures:

- Field instruments will be checked and calibrated prior to their use on site. Batteries will be charged and checked daily where applicable.

- Equipment that fails calibration and/or becomes otherwise inoperable during the field investigation will be removed from service and segregated to prevent inadvertent use. Such equipment will be properly tagged to indicate that it should not be used until the nature of the problem can be determined.
- Equipment requiring repair or recalibration must be approved for use by the site manager or Site Health and Safety Officer prior to placement back into service. Equipment that cannot be repaired or recalibrated will be replaced.

Calibration of the Horiba U-10 Water Quality Checker is usually done with one calibration solution in accordance with the manufacturer's specifications. However, should it become necessary to use other water quality monitoring instruments, the following calibration procedures may be used.

pH Meter

Calibration of the pH meter should follow the manufacturer's specific instructions. In general, calibration is done by adjusting the meter with standard buffers that bracket the expected pH of the field water. Calibration will consist of the following general procedures:

1. Adjust the reading of the pH meter with the electrode placed in the pH 7 buffer by using the calibration knob. Rinse the electrodes with distilled water between buffer adjustments.
2. Adjust the reading of the meter with the electrode placed in the pH 4 buffer with the slope (or temperature) knob.
3. Repeat steps 1 and 2 until the meter gives acceptable readings ($\pm$0.1 pH unit) for all the buffers used for calibration.

Temperature Meter

Calibration of the temperature meter should follow the manufacturer's specific instructions.

Turbidity Meter

Calibration of the turbidity meter should follow the manufacturer's specific instructions.

Dissolved Oxygen Meter

Calibration of the dissolved oxygen meter should follow the manufacturer's specific instructions. Calibration is accomplished by exposing the probe to a known oxygen concentration, such as water-saturated air (%), or water of a known oxygen content (mg/L), and then adjusting the calibration controls so the display shows a reading matching the oxygen concentration of the known sample.

Calibration will consist of the following general procedures:

1. Place the probe in moist air. Biological Oxygen Demand (BOD) probes can be placed in partially filled (50 ml) BOD bottles. Wait 10 minutes for temperature stabilize within a ± 2 degree C range.

2. Turn the meter's switch to temperature and read. Determine the solubility of oxygen in fresh water (calibration value).

3. Determine altitude or atmospheric correction factor.

4. Multiply the calibration value by the atmospheric correction factor to obtain the corrected solubility value for instrument calibration value.

   EXAMPLE: Assume a temperature of 20 degrees C and an altitude of 1100 ft. From Table 1, the calibration value of solubility of oxygen in water 20 degrees C is 9.09 mg/L. From Table 2, the atmospheric correction factor for 1100 ft is 0.96. Therefore, the corrected calibration value solubility is 9.09 mg/L x 0.96 = 8.73 mg/L.

5. Switch to the appropriate mg/L range, set the salinity knob to zero and adjust the calibrate knob until the meter reads the corrected solubility calculated in Step 4. Wait two minutes to verify calibration stability. Readjust if necessary.

Specific Conductance Meter

Calibration of the conductivity meter should follow the manufacturer's specific instructions. In general, calibration is done by noting the response of the meter to several standard conductivity solutions which bracket the values expected to be measured in the field. Adjust the calibration controls so the display shows a reading matching the value of the standard solution.

2.3 Operating Procedures

Operation of the Horiba U-10 Water Quality Checker will be done in accordance with manufacturer's specifications. However, should it become necessary to use other water quality monitoring instruments, the following procedures may be used.

pH Meter

Operating procedures should follow manufacturer's specifications. Generally, operating procedures are as follows:

Connect the ATC and pH electrodes to the appropriate inputs.

1. Turn on instrument, clear instrument.
2. Rinse a small beaker with distilled water. Fill the beaker with sample water.
3. Rinse the probes with distilled water. Blot excess.
4. Immerse the probes in the sample and swirl gently, keeping the probes in the sample until the display stops flashing.
5. Record the sample pH and temperature after stabilization. Note any problems such as meter drift.
6. Rinse the probes with distilled water. Blot excess.
7. Repeat steps 3-7 for additional samples.

Temperature Meter

Operating procedures should follow manufacturer's specific instructions. Generally, operating procedures are as follows:

1. Rinse the probe with distilled water.
2. Insert the probe into the sample, and leave in the sample until temperature stabilizes.
3. Record the temperature reading, being sure to indicate degrees C or degrees F.

****

Note: degrees C = (degrees F - 32) (5/9)

degrees F = ((9/5)C degrees) + 32

****

Turbidity Meter

Operating procedures should follow manufacturer's specific instructions. Generally, operating procedures are as follows:

1. Pour aqueous sample into a new curette assuring no air bubbles.
2. Place curette in turbidity meter.
3. Allow the turbidity meter to stabilize before recording the NTU value.

4. Do not leave the filled curette in the sample well for long periods of time.
5. Repeat steps 1-4 for additional samples.

Dissolved Oxygen Meter

Operating procedures should follow manufacturer's specific instructions. Generally, operating procedures are as follows:

1. Pour aqueous sample into a clean beaker assuring no air bubbles.
2. Place the probe in the sample.
3. Turn the stirrer knob on.
4. Adjust the salinity knob to the salinity of the sample if appropriate.
5. Allow sufficient time for the probe to equilibrate to the sample's temperature and dissolved oxygen content.
6. Read dissolved oxygen on appropriate scale.
7. Rinse probe and sample beaker with distilled water and then with next water sample.
8. Follow steps 1-7 for additional samples.

****

Note: The DO meter should be left on during the working day to avoid waiting for probe repolarization.

****

Specific Conductance Meter:

Operating procedures should follow manufacturer's specific instructions. Generally, operating procedures are as follows:

1. Rinse probe and sample beaker with distilled water and then with sample water.
2. Measure the temperature of the sample water.
3. Place the probe in the sample beaker with enough sample to completely submerge the probe. Swirl the probe to remove any air bubbles trapped in the probe.
4. Select the highest multiplier scale on the meter and turn the instrument on. Progressively use lower multiplier scales until a mid-scale deflection is obtained.

5. If appropriate, check probe accuracy by pressing cell test button. If value change is > 10% check probe.
6. Record the temperature and conductivity values.

Maintenance

- All field instrumentation, sampling equipment, and accessories will be maintained in accordance with the manufacturer's recommendations and specifications and established field practice.
- All maintenance will be performed by qualified project personnel and will be documented by the appointed equipment manager or designee under the direction of the equipment manager.
- All field instruments will be properly protected against inclement weather conditions during the field investigation. Each instrument is specially designed to maintain its operating integrity during variable temperature ranges that are representative of ranges that will be encountered during expected working conditions.
- At the end of each working day, all field equipment will be taken out of the field and placed in a dry room for overnight storage.

2.4 Sample Identification, Handling, and Documentation

Samples will be identified, handled, and recorded as described in this SOP and in SOP No. 7, SOP No. 25 and SOP No. 26.

Documentation

The following information should be recorded in the field log book:

- Calibration of equipment will be recorded in the field logbook to document that appropriate procedures have been followed.
- Calibration will also be recorded on a calibration log. Entries made on the equipment calibration log regarding the status of any field equipment will contain, but are not necessarily limited to, the following information:
    1. Date and time of calibration
    2. Name of person doing calibration
    3. Type of equipment being serviced, and identification number (such as serial number)
    4. Reference standard used for calibration (such as pH of buffer solutions)

5. Calibration and/or maintenance procedure used
6. Any problems or other pertinent information.

- Each reading taken for a particular sample will be recorded in the field logbook and on a field form. Entries will include, but are not limited to the following:

1. Date and time of reading
2. Type of reading
3. Value of reading with units
4. Any problems or other pertinent information.

1. Introduction and Types of Contamination

This document defines the standard procedure for decontamination. This SOP serves as a supplement to the Work Plan Addendum and Sampling and Analysis Plan Addendum and is intended to be used together with several other SOPs. Other related SOPs are listed below:

- SOP No. 6 - EnCore™ Sampling
- SOP No. 8 - Field Reporting and Documentation
- SOP No. 10 - Groundwater Level Measurements
- SOP No. 11 - Groundwater Sampling
- SOP No. 20 – Monitoring Well Development and Purging
- SOP No. 21 - Monitoring Well Installation
- SOP No. 26 - Sample Control and Custody Procedures
- SOP No. 28 - Soil Sampling
- SOP No. 31 - Surface Water Sampling
- SOP No. 32 - Sediment Sampling

Site and/or Sample Cross-Contamination

The overall objective of multimedia sampling programs is to obtain samples that accurately depict the chemical, physical, and/or biological conditions at the sampling site. Extraneous contaminants can be brought onto the sampling location and/or introduced into the medium of interest during the sampling program (e.g. using sampling equipment that is not properly or fully decontaminated). Trace quantities of contaminants can consequently be captured in a sample and lead to false positive analytical results and, ultimately, to an incorrect assessment of the contaminant conditions associated with the site. Decontamination of sampling equipment (e.g., all non-disposable equipment that will come in direct contact with samples) and field support equipment (e.g., drill rigs, vehicles) is, therefore, required prior to, between, and after uses to ensure that sampling cross-contamination is prevented, and that on-site contaminants are not carried off-site.

2. Procedure

2.1 Equipment List

The following is a list of equipment that may be needed to perform decontamination:

- Brushes
- Wash tubs
- Buckets
- Scrapers, flat bladed
- Hot water - high-pressure sprayer
- Sponges or paper towels
- Alconox detergent (or equivalent)
- Potable tap water
- Laboratory-grade deionized or distilled water
- Garden-type water sprayers

2.2 Decontamination

2.2.1 Personnel

A temporary personnel decontamination line will be set up around each exclusion zone. If contamination is not encountered, a dry decontamination station may be established which consists of discarding of disposable personal protective equipment (PPE).

If real-time monitoring instruments indicate that contamination has been encountered, (i.e. action levels are exceeded requiring an upgrade from initial PPE levels), a complete personnel decontamination station will be established.

The temporary decontamination line should provide space to wash and rinse boots, gloves, and all sampling or measuring equipment prior to placing the equipment into a vehicle. A container should be available to dispose of used disposable items such as gloves, tape, or tyvek (if used).

The decontamination procedure for field personnel will include:

1. Glove and boot wash in an Alconox solution
2. Glove and boot rinse
3. Duct tape removal
4. Outer glove removal
5. Coverall removal
6. Respirator removal (if used)
7. Inner glove removal

2.2.2 Sampling Equipment

The following steps will be used to decontaminate sampling equipment:

- Personnel will dress in suitable safety equipment to reduce personal exposure as required by the HASP.
- Gross contamination on equipment will be scraped off at the sampling or construction site.
- Equipment that cannot be damaged by water will be placed in a wash tub containing Alconox or low-sudsing nonphosphatic detergent along with potable water and scrubbed with a bristle brush or similar utensil. Equipment will be rinsed with tap water in a second wash tub followed by a deionized or distilled water rinse.
- Equipment that may be damaged by water will be carefully wiped clean using a sponge and detergent water and rinsed with deionized or distilled water. Care will be taken to prevent equipment damage.
- Rinse and detergent water will be replaced with new solutions between borings or sample locations.

Following decontamination, equipment will be placed in a clean area or on clean plastic sheeting to prevent contact with contaminated soil. If the equipment is not used immediately after decontamination, the equipment will be covered or wrapped in plastic sheeting or heavy-duty trash bags to minimize potential contact with contaminants.

2.2.3 Drilling and Heavy Equipment

Drilling rigs will be decontaminated at a decontamination station located near a central staging area. The decontamination station may consist of a temporary or permanent structure capable of collecting all decontamination fluids. Mobile decontamination trailers may be used to decontaminate heavy equipment at each site. The following steps will be used to decontaminate drilling and heavy equipment:

- Personnel will dress in suitable PPE to reduce personal exposure as required by the HSP.
- Equipment showing gross contamination or having caked-on drill cuttings will be scraped with a flat-bladed scraper at the sampling or construction site.
- Equipment that cannot be damaged by water, such as drill rigs, augers, drill bits, and shovels, will be washed with a hot water, high-pressure sprayer then rinsed with potable water. Care will be taken to adequately clean the insides of the hollow-stem augers and backhoe buckets.

Following decontamination, drilling equipment will be placed on the clean drill rig and moved to a clean area. If the equipment is not used immediately, it should be stored in a designated clean area.

2.2.4 Equipment Leaving the Site

Vehicles used for activities in non-contaminated areas shall be cleaned on an as-needed basis, as determined by the Site Safety Officer, using soap and water on the outside and vacuuming the inside. On-site cleaning will be required for very dirty vehicles leaving the area. Construction equipment such as trucks, drilling rigs, backhoes, trailers, etc., will be pressure washed before the equipment is removed from the site to limit exposure of off-site personnel to potential contaminants.

2.2.5 Wastewater

Liquid waste water from decontamination, well development and purging will be containerized and left at the site where it originated, unless otherwise specified.

3. Documentation

Sampling personnel will be responsible for documenting the decontamination of sampling and drilling equipment. The documentation will be recorded with waterproof ink in the sampler's field notebook with consecutively numbered pages. The information entered in the field book concerning decontamination should include the following:

- Decontamination personnel
- Date and start and end times
- Decontamination observations

- Weather conditions

4. Quality Assurance Requirements

Equipment rinsate samples of the decontaminated sampling equipment may be taken to verify the effectiveness of the decontamination procedures. The rinsate sampling procedure will include rinsing deionized water through or over a decontaminated sampling tool (such as a split spoon) and collecting the rinsate water into the appropriate sample bottles. The rinsate sampling procedure, including the sample number, will be recorded in the field notebook.

This document defines the standard procedure for field reporting and documentation. This procedure provides descriptions of equipment and field procedures necessary to properly document field activities.

1. Equipment

Equipment used during field reporting and documentation:

- Calculator
- Bound field logbook
- Waterproof pen and permanent marker
- Well completion information form (if necessary)
- Groundwater sampling form (if necessary)
- Boring log (if necessary)
- Other related field paperwork, as needed.

2. Field Reporting and Documentation

Documentation of observations and data acquired in the field will provide information on the acquisition of samples and also provide a permanent record of field activities. The observations and data will be recorded using pens with permanent waterproof ink in a permanently bound weatherproof field logbook.

Field investigation situations vary widely. No set of general rules can anticipate all information that must be entered in a logbook for a particular site. A site-specific logging procedure will be developed to include sufficient information so that the sampling activity can be reconstructed without relying on the memory of field personnel. The logbooks will be kept in the field team member's possession or in a secure place during the investigation.

Each project should have a dedicated logbook. The project leader's name, the sample team leader' s name (if appropriate), the project name and location, and the project number should be entered on the inside of the front cover of the logbook. It is recommended that each page in the logbook shall be numbered and dated. The entries should be legible and contain accurate and inclusive documentation of an individual's project activities. At the end of the all entries for each day, or at the end of a particular event, if appropriate, the investigator shall draw a diagonal line and initial and date indicating the conclusion of the entry. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and must be maintained as part of the official project files. All aspects of sample collection and handling, as well as visual observations, shall be documented in the logbooks.

The information in the field book will include the following as a minimum.

- Personnel present
- Level of PPE used during sampling
- Weather conditions
- Names and responsibilities of field crew members
- Names and title of any site visitors
- Field analytical equipment, and equipment utilized to make physical measurements shall be identified
- Sample collection equipment (where appropriate)
- Calibration results of field equipment
- Location of Sample
- Description of samples (matrix sampled)
- Results of any field measurements, such as depth to water, pH, temperature, and conductivity
- Sample depth (if applicable)
- Date and time of sample collection
- Sample identification code including QC and QA identification
- Number and volume of samples
- Sampling methods or reference to the appropriate SOP
- Sample handling, including filtration and preservation, as appropriate for separate sample aliquots
- Analytes of interest
- Information concerning sampling changes, scheduling modifications, and change orders
- Field observations

- Summary of daily tasks
- Signature and date by personnel responsible for observations
- Problems identified with equipment or aspects of the project

Changes or deletions in the field book should be lined out with a single strike mark, initialed, and remain legible. Sufficient information should be recorded to allow the sampling event to be reconstructed without relying on the sampler's memory.

Each page in the field books will be signed by the person making the entry at the end of the day, as well as on the bottom of each page. Anyone making entries in another person's field book will sign and date those entries.

3. Document Control

Document control refers to the maintenance of inspection and investigation project files. All information below shall be kept in project files. Investigators may keep copies of reports in their personal files, however, all official and original documents relating to inspections and investigations shall be placed in the official project files. The following documents shall be placed in the project file, if applicable:

- Chain-of-Custody Records and bound field logbooks
- Records obtained during the investigation
- Complete copy of the analytical data and memorandums transmitting analytical data
- Official correspondence received or transmitted, including records of telephone calls
- Photographs and negatives associated with the project
- One copy of the final report and transmittal memorandum
- Relevant documents related to the original investigation/inspection or follow-up activities related to the investigation/inspection

Inappropriate personal observations and irrelevant information should not be placed in the official project files. At the conclusion of the project, the project leader shall review the file to ensure that it is complete.

1. Objective

This document defines the standard procedure for collection of soil samples for environmental characterization purposes. This procedure provides descriptions of equipment and field procedures necessary to collect soil samples. Other related SOPs are listed below:

- SOP No. 4 – Decontamination
- SOP No. 6 – EnCore™ Sampling
- SOP No. 8 – Field Reporting and Documentation
- SOP No. 14 - Headspace Soil Screening
- SOP No. 24 – Sample Classification, Packaging and Shipping
- SOP No. 25 – Sample Containers, Preservation, and Holding Times
- SOP No. 26 – Sample Control and Custody Procedures.

2. Equipment

The following equipment is typically used to collect soil samples:

- Hand Auger (if required to collect sample)
- Latex/Nitrile gloves
- Organic Vapor meter (e.g. PID, OVA)
- Surveyor's stakes
- Portable field table
- Stainless steel pans and knives
- Stainless steel spoon or scoop
- Stainless steel bowl
- Sample containers
- Decontamination equipment
- Plastic Sheeting
- Field data sheets/bound field logbook
- Health & Safety equipment

- Cooler with ice.

3. Soil Sample Collection Procedures

This section provides step-by-step procedures for collecting soil samples in the field. Observations made during soil sample collection should be recorded in a bound field logbook in accordance with the procedures defined in SOP No. 8 on field reporting and documentation:

A. Remove appropriate sample containers from the transport container, and prepare the sample containers for receiving samples.

B. Fill out a self-adhesive label with the appropriate information and affix it to the appropriate sample container. Place clear polyethylene tape over the completed label to protect it from dirt and water. Sample labels can be prepared prior to sample collection except for time and date. Labels can be filled in on the date of sample collection and just prior to collecting the sample. Sample containers will be kept cool with their caps on until they are ready to receive samples.

C. Place labeled sample containers near the sampling location.

D. Place clean plastic sheeting on the ground surface at the sampling area as needed.

E. Put on a pair of new nitrile or latex gloves.

F. Decontaminate the sampling equipment as described in detail in SOP No. 4 prior to beginning sampling activities.

G. Advance the sampler (direct push sampler, hand auger, split-spoon, etc.) to the desired sample depth and retrieve the sample.

H. VOC samples cannot be composited without losing volatiles. Therefore, collect a discrete VOC sample prior to compositing the remaining soil (if doing so). Collect the VOC sample with an EnCore™ sampler, using the Methanol preservation method, or by placing it directly into an appropriate sample container. Additional information is available in SOP No. 6 – EnCore™ Sampling. If the sample is transferred to a jar, the entire jar must be filled without any voids and the top surface of the soil should be smeared to prevent VOCs from escaping when opening the jar. After collecting the sample at the desired location within the sample interval, place the remainder of the sample into a stainless steel bowl/Ziploc bag, break up large chunks and mix the soil. Fill the remaining sample containers from the steel bowl.

I. Place the sample containers on ice in a cooler to maintain the samples at approximately 4^{o}C as described in SOP No. 25. Ship the cooler to the laboratory for analysis within 24 hours of sample collection in accordance with the procedures described in SOP No. 24.

J. Begin chain-of-custody procedures. A sample chain-of-custody form is included in SOP No. 26.

K. Decontaminate the sample equipment as described in detail in SOP No. 4.

L. Field notes shall be kept in a bound field logbook.

4. Possible Soil Sample Collection Methods

A. Geoprobe (micro or macro samplers)

B. Split Spoon sampler using a conventional drill rig

C. Hand Auger

D. Surface Sampling with a stainless steel spoon or scoop.

1. Objective

Collection of soil samples for low level VOC analysis that will minimize the loss of contaminants due to volatilization and biodegradation

2. Equipment

The following equipment is required for each sample point.

- Stainless steel T-Handle
- Two or three 5 g EnCore™ samplers (laboratory specific)
- One 125 mL jar or one 25 g EnCore™ sampler for screening and or/high level analysis, and dry weight conversions (laboratory specific)
- Paper towels
- Indelible pen
- Clear Tape and Labels.

3. Sample Collection Procedure

The following general procedures are followed for collection of soil samples with the EnCore™ sampler:

1. Remove sampler and cap from package and attach T-handle to sampler body
2. Inspect sampler piston to ensure it can be pushed up to accommodate soil core
3. Push the T-handle and sampler straight down into a freshly exposed surface of soil until the sampler is full.
4. Slowly remove sampler and T-handle and inspect bottom of sampler. If sampler is not full, repeat step 3;
5. Remove excess soil from the sampler rim lip
6. Place cap on sampler and push down evenly until the end cap clicks on the sampler body;
7. Turn the sampler piston until it locks to prevent the sample core from being extruded.
8. Repeat procedures 1 through 7 for the other EnCore™ samplers.
9. Place EnCore™ samplers in EnCore™ packages and attach sample label.
10. Secure label with clear tape and place in cooler, keep sample at 4° Celsius.

11. Collect additional soil and place in glass jar or 25 mg sampler to be used for dry weight conversion.

1. Objective

This document defines the standard operating procedure (SOP) and necessary equipment for collection of groundwater profiling samples within hydraulically advanced GeoProbe® (or similar) hollow drill rods and well screens using a peristaltic pump or ball and check valve.

During groundwater profiling activities, groundwater samples are collected at predetermined intervals from the top of the uppermost aquifer to the base of the lower aquifer. Sampling intervals are specified in the Scope of Work for a specific site. Groundwater samples are collected by using a GeoProbe® to hydraulically advance a 4-foot stainless steel slotted sampler with a screen slot size of 0.002 inches to pre-determined intervals below ground surface. In this technique, in order to lessen drawdown within the hollow drill rods, a pump that minimizes disturbance to the groundwater is operated at the lowest possible flow rate. Purging is performed until specific parameters have stabilized as specified in the Work Plan over three consecutive flow-through cell volumes or until one hour of purge time has elapsed, whichever occurs first. Therefore, the groundwater samples collected are representative of the water bearing formation and hydraulically isolated from the water in the casing.

SOPs providing additional related guidance are listed below:

- SOP No. 4 – Decontamination
- SOP No. 8 – Field Reporting and Documentation
- SOP No. 10 – Groundwater Level Measurements
- SOP No. 18 – Low-Flow Groundwater Purging and Sampling
- SOP No. 20 – Monitoring Well Development and Purging
- SOP No. 24 – Sample Classification, Packaging and Shipping
- SOP No. 25 – Sample Containers, Preservation, and Holding Times
- SOP No. 26 – Sample Control and Custody Procedures.

2. Equipment

Equipment used during well purging and sampling:

- Polyethylene tubing
- Ball and check valve
- Disposable latex or nitrile gloves

- Assorted tools (knife, screwdriver, etc.)
- Pump and required accessories (described in more detail in following section)
- Electronic water level indicator with 0.01-foot increments
- Graduated cylinder
- Temperature meter
- pH meter (with automatic temperature compensation)
- Conductivity meter
- Turbidity meter
- Dissolved oxygen (DO) meter
- Oxidation reduction potential (ORP) meter
- Flow-through cell
- Calibration fluids
- Paper towels or Kimwipes
- Calculator
- Bound field logbook (logbook)
- Waterproof pen and permanent marker
- Plastic buckets
- 55-gallon drums or truck-mounted tank
- Plastic sheeting
- Appropriate decontamination equipment (see SOP No. 4)
- Cooler with ice
- Sample containers and labels
- Groundwater sampling form
- Chain-of-Custody form
- Appropriate health and safety equipment (e.g., photoionization detector (PID)).

3. Sampling Procedure

This section provides the step-by-step procedure for collecting groundwater profile samples in the field. Observations made during groundwater purging and sampling should be recorded in a logbook in accordance with procedures described in SOP No. 8.

A. Any equipment used in the profile sampling procedure that could contact groundwater should be properly decontaminated before each use (see SOP No.4).

B. Equipment should be calibrated based on the manufacturers' instructions. The frequency of calibration should be specified in the site-specific Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP) or work plan. Dissolved oxygen calibration must be corrected for local barometric pressure readings and elevation.

C. Underground utilities at the location of each soil probe will be cleared prior to commencement of probing activities. Following utility clearance the 4-foot sampler will be advanced to the predetermined depth and opened. A groundwater measurement of the water within the screen and rods will be collected to the nearest 1/100th of a foot. Measurements will be recorded in the logbook and any pertinent field forms. The volume of water within the screen and rods will then be calculated.

D. Following measurement of the static groundwater elevation, the appropriate equipment will be slowly and carefully placed in the well. If the wells have light or dense non-aqueous-phase liquids (LNAPLs or DNAPLs) care should be taken to place sampling equipment below or above the NAPL.

   When placing the equipment in the well, the pump intake should be set near the middle or slightly above the middle of the screened interval. If the screen length allows, the pump intake should be at least two feet from the bottom of the screen. Placing the pump intake near the top of the water column can cause stagnant water from the casing to be purged, but placing the pump intake near to the bottom of the well can cause mobilization and entrainment of settled solids from the bottom of the well.

E. Tubing should be connected from the pump to a flow-through cell. New tubing should be used for each profiling interval.

F. The pump should be started at a low flow rate, approximately 100 mL/min or the lowest flow rate possible.

G. After the relevant parameters have stabilized or the required purging time has elapsed, the flow-through cell should be disconnected or bypassed for sampling. Samples will be collected by allowing the groundwater to flow from the tubing directly into the laboratory supplied containers.

H. The flow rate should be adjusted to less than 0.5 L/min for sampling to minimize aeration during the sampling of volatiles.

I. A new pair of disposable latex or nitrile gloves should be put on immediately before sampling.

J. The constituents should be sampled for in the order given below:

- VOCs – Vials should be filled completely so that the water forms a convex meniscus then capped so that no air space exists in the vial. Turn the vial over and tap it to check for bubbles. If air bubbles are observed in the sample vial, remove the lid and attempt to fill the vial two more times, (being careful not to dump out any groundwater currently in the vial). If air bubbles are present twice more, discard the sample vial and repeat the procedure with a new vial. If, after three attempts, air bubbles are still in the vial, make a note of this and place the vial in the cooler.
- Gas sensitive parameters (e.g., ferrous iron, methane, alkalinity)
- Semivolatile organic compounds, pesticides, polychlorinated biphenyls, and herbicides
- Petroleum hydrocarbons
- Metals (unfiltered)
- Explosives
- Any filtered analytes (use in-line filters if possible).

K. Place all samples on ice inside a cooler immediately.

L. Each sample should be identified with the Sample ID, location, analysis number, preservatives, date and time of sampling event, and sampler.

M. The sample time and constituents to be analyzed for should be recorded in the logbook and on the groundwater sampling form.

N. Chain-of-custody procedures should be started.

O. Sample equipment should be decontaminated or replaced as applicable.

P. The GeoProbe® sampler should then be advanced to the next predetermined profiling depth and the process of purging and sampling repeated.

Q. Upon completion of each alluvial aquifer boring, each GeoProbe® hole will be sealed with grout from the bottom up using the GeoProbe® rods as a tremie pipe and the surface will be returned to the original condition. Purge water will be placed in 55-gallon drums (or similar) that are labeled, sealed, and staged at a pre-determined location on-site. The GeoProbe® unit and rods will be cleaned between profiling holes using a steam pressure washer. Wash water will be containerized in 55-gallon drums (or similar) and labeled.

4. List of Potential Suppliers Who Provide Pumps Suitable for Groundwater Profile Sampling

Field Environmental. 1-800-3930-4009. www.fieldenvironmental.com. Pumps: peristaltic, QED bladder pumps, Fultz rotor pump, control boxes, compressors, etc.

QED. 1-800-624-2026. www.micropurge.com. Pumps: bladder pumps, flow cell, compressors, etc.

Fultz Pumps. 1-717-248-2300. www.fultzpumps.com.

1. Objective

Volatile Organic Compound (VOC) field headspace screenings will be performed on selected soil samples to obtain preliminary estimates of VOC concentrations. This qualitative data will be used as a criteria in selecting soil samples from locations where collection depths have not been predetermined.

2. Equipment

The following equipment is required.

- Quart-sized Zip-Loc bag or equivalent
- Photoionization detector (PID)
- Permanent Marker
- Watch.

3. Procedure

The following general procedure is followed:

1. Obtain approximately 1/2 qt of soil and place in clean 1 qt Zip-Loc bag. Immediately seal the Zip-Loc bag. Record the boring location and sample depth on the bag.
2. Break soil into about 1 in. sized particles by squeezing the bag, taking care not to compromise the seal.
3. Place sample in a shaded location where it can be left undisturbed for a minimum of 5 minutes. If the temperature is less than 35^{o} F place the sample bag in a heated vehicle or building.
4. Measure ambient air background VOC concentrations.
5. After at least 5 minutes has elapsed, obtain PID reading from bag headspace by opening a space in the bag seal just large enough to allow the PID probe to enter unobstructed. Continue monitoring until PID readings drop to background concentrations.
6. Record highest PID reading measured.
7. Archive or dispose of soil per site field sampling plan.

1. Purpose and Scope

This document defines the Standard Operating Procedure (SOP) for performing the hydrophobic dye test (Sudan IV™). Described within this document are the needed equipment, field testing procedures and documentation of the activity required to properly perform the hydrophobic dye test.

This SOP serves as a supplement to the Work Plan and is intended to be used together with other SOPs. Other related SOPs are listed below:

- SOP No. 4 – Decontamination
- SOP No. 8 – Field Reporting and Documentation

Health and safety procedures and equipment that will be required during the investigation are detailed in the HSP.

These procedures are to be strictly followed. Any modifications to this SOP must be approved by the project manager or task leader and the QA/QC officer.

A goal of the hydrophobic dye test is to determine the presence of non-aqueous phase liquids (NAPL) in saturated soils and groundwater. The OilScreenSoil™ test kits can typically be used with a wide range of petroleum hydrocarbon products including: Automotive Gasoline, Jet Fuel, Fuel Oil, Mineral Oils, and Chlorinated Solvents. Details are provided regarding this procedure so that all sampling personnel following these procedures will collect samples in a consistent and documented manner, resulting in acceptable data.

2. Procedures for Collecting Sediment Samples

2.1 Performing Hydrophobic Dye Test

The following list of equipment will be needed to execute the hydrophobic dye test (Sudan IV™):

Equipment List

- Applicable field logbook
- Indelible ink pen
- Stainless-steel sampling spoon or trowel
- Potable/Distilled Water
- OilScreenSoil™ Test Kit with Sudan IV™ dye

- Styrene bottle
- a label indicating recommended soil and water levels
- a small Styrofoam(polystyrene) ball
- and a cube containing dyes which is glued to the inside of the jar lid

The following Health and Safety Items may be required:

- PPE
- PID (Photoionization detector).

Before sampling begins, the sampling equipment will be decontaminated according to the procedures contained in SOP No. 4.

Sampling Procedures

The following procedure should be used when using the OilScreenSoil™ – Sudan IV™ screening test kit.

1. Record the sample location on a site base map and in the field log book.
2. Gather the sample from the target depth with a stainless-steel sampling spoon, or trowel.
3. Fill the bottle with soil to the line "*Fill soil to HERE*"→ Note: Do not compact the soil.
4. Fill the bottle with water to the line "*Fill water to HERE*"→ Note: ensure water is warm enough to dissolve the cube.
5. Replace cap on bottle and shake jar until cube is **completely** dissolved
6. Compile applicable information in the field logbook.

2.2 Data Interpretation and Reporting

If DNAPL or petroleum is present in the sample a red meniscus (or red spots on the side of the jar) will appear within 30-60 seconds. If color is not immediately apparent in the jar – Check the polystyrene ball. The presence of ANY color on the ball (even a faint pink halo or hue) indicates the presence of more than 500ppm Total Petroleum Hydrocarbons (TPH) in the sample material. Conversely, a "clean" ball indicates that there is less than 500ppm TPH

A field logbook should include date, time, matrix description, (i.e. soil type or groundwater description), temperature, location, depth, and observations of test kit results.

Note: Most DNAPLs dissolve styrene. Therefore, red spots may appear on the sides of the jar.

<u>Note</u>: Whenever possible, use potable water for the screening tests. However, salt water can be used if necessary

Cold Water can inhibit the rapid release of viscous hydrocarbons from soil and cause False Negative results. Therefore, at a temperature below 68°F (20°C), a thermos of hot water for field testing purposes can be used.

2.3 Recommended Protective Equipment

<u>Airborne Exposure Limits</u>

None established.

<u>Ventilation System</u>

A system of local and/or general exhaust is recommended to keep employee exposures as low as possible. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

<u>Personal Respirators (NIOSH Approved)</u>

For conditions of use where exposure to the substance is apparent and engineering controls are not feasible, consult an industrial hygienist. For emergencies, or instances where the exposure levels are not known, use a full-face positive-pressure, air-supplied respirator. WARNING: Air purifying respirators do not protect workers in oxygen-deficient atmospheres.

<u>Skin Protection</u>

Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

<u>Eye Protection</u>

Use chemical safety goggles and/or full-face shield where dusting or splashing of solutions is possible. Maintain eye wash fountain and quick-drench facilities in work area.

<u>Other Control Measures</u>

There is insufficient data in the published literature to assign complete numerical SAF-T-DATA* ratings and laboratory protective equipment for this product. Special precautions must be used in storage, use and handling. Protective equipment for laboratory bench use should be chosen using professional judgment based on the size and type of reaction or test to be conducted and the available ventilation, with overriding consideration to minimize contact with the chemical.

3. References

New Jersey Department of Environmental Protection. 1993. Hydrophobic Dye Test for Determination of NAPL in Saturated Soils and Groundwater Samples. Prepared by the Site Remediation Programs Hazardous Site Science Element Division.

Sudan IV; MSDS No. C.I.26105; Mallinckrodt Baker: Phillipsburg, NJ, November 10, 2005.

Cheiron Resources Ltd. (-NA-). *OilScreenSoil Sudan IV Field Screening Test Instruction Manual*. Calgary, AV: Cheiron Resourced Ltd.

1. Purpose and Scope

This document defines the Standard Operating Procedure (SOP) for monitoring well screening for NAPL. This SOP describes the needed equipment, field procedures for monitoring well screening and decontamination of equipment, and documentation of the activity.

This SOP serves as a supplement to the Work Plan and is intended to be used together with other SOPs. Other related SOPs are listed below:

- SOP No. 3 – Calibration and Maintenance of Field Instruments
- SOP No. 4 – Decontamination
- SOP No. 8 – Field Reporting and Documentation

Health and safety procedures and equipment that will be required during the investigation are detailed in the HSP.

These procedures are to be strictly followed. Any modifications to this SOP must be approved by the project manager or task leader and the QA/QC officer.

The three monitoring wells installed as part of the NAPL investigation will be surveyed to evaluate the possible presence of light and dense non-aqueous phase liquids (LNAPL and DNAPL). Ground water levels will be measured using an electronic interface probe, and a weighted tape measure. Details are provided in this procedure so that all sampling personnel following these procedures will collect samples in a consistent and documented manner, resulting in acceptable data.

2. Procedures for Monitoring Well Screening

The following list of equipment will be needed for monitoring well screening:

Equipment List

- Applicable field logbook
- Indelible ink pen
- Weighted tape measure with 0.1-foot increments
- Cotton String (one for every well tested)
- Bailer cord (one for every well tested)
- Disposable clean bailer made of Teflon or PVC (one for every well tested)
- Weight (for end of cotton string)

- Electronic interface probe

The following Health and Safety Items may be required:

- PPE
- PID (Photoionization detector).

Before sampling begins, the sampling equipment will be decontaminated according to the procedures contained in SOP No. 4.

Sampling Procedures

The following procedure should be followed for monitoring well screening.

1. Record the sample location on a site base map and in the field log book.
2. Obtain background (BG) PID readings at the sampling location, just above the sediment and in the breathing zone.
3. At each well, measure the depth to water to the nearest 0.01 ft using the weighted tape measure. All water-level measurements will be taken from an obvious survey mark at the top edge of the well casing.
4. One standard piece of equipment for making individual water-level measurements, at each well, will be an electronic interface probe. The probe must have firmly affixed or permanent marks on its cable at regular intervals (minimum interval of 0.01 foot). If free-phase hydrocarbon is present, measurement of hydrocarbon thickness and water level will be made.

   Note: When the probe enters a liquid you will hear an audible tone. If the liquid is a non-conductive oil/product the signals are steady. If the liquid is water, the conductivity of the water completes a conductivity circuit. This overrides the infra-red circuit, and the tone is intermittent.

   Note: Portions of the cable that are inserted in wells will be decontamination after use according to the procedures described in SOP 4. This device must be kept in a clean and functioning condition.

5. At each well, a visual check for LNAPL will be performed by attaching a disposable clear bailer made of Teflon or PVC to a bailer cord, lowering bailer to the water level, and inspecting bailer for the presence or absence of LNAPL

6. At each well, a visual check for DNAPL will be performed by lowering a weighted cotton sting to the bottom of the well. The string will be retrieved after lowering and inspected for evidence of staining.
7. At each well, the disposable bailer will be lowered to the bottom of the well to check for the presence of accumulated DNAPL.

   Note: new string, bailers, and bailer cord will be used at each well.

8. The applicable information is compiled in the field logbook.

Field Logbooks and Documentation

Each field activity must be properly documented to facilitate a timely and accurate reconstruction of events in the field. Observations and data acquired in the field will be recorded with black ink in a bound weatherproof field book with consecutively numbered pages. A field logbook should include but is not limited to date, time, temperature, location, depth, results from electronic interface probe, observations from visual LNAPL test, observations from visual DNAPL test, observations from accumulated DNAPL test, and any other pertinent observations.

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6. At each well, a visual check for DNAPL will be performed by lowering a weighted cotton sting to the bottom of the well. The string will be retrieved after lowering and inspected for evidence of staining.
7. At each well, the disposable bailer will be lowered to the bottom of the well to check for the presence of accumulated DNAPL.

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Gross contamination will be assumed to be present if any one of the following conditions is observed:

- Drum or drum remnants are present;
- A visual screen of the soil finds NAPL staining or droplets, or presence of a sheen;
- Distinct discoloration of the soil that is laterally or vertically extensive (i.e., more than a few feet in either dimension);
- Strong organic chemical or hydrocarbon odor combined with distinct discoloration and/or elevated PID readings;
- If PID readings are observed during screening above 50 ppm, a headspace reading should be conducted. Headspace readings greater than 100 ppm is considered gross contamination.

STL Savannah 5102 LaRoche Avenue - Savannah GA 31404 Telephone:(912) 354-7858 Fax:(912) 351-3673

Analytical Report

For: Mr. Jorge Garcia
Solutia Inc.
575 Maryville Center Dr.
St. Louis, MO 63141
CC:

Order Number:	S243137
SDG Number:	
Client Project ID:	
Project:	RM842100
Report Date:	05/20/2002
Sampled By:	Client
Sample Received Date:	05/07/2002
Requisition Number:	V#203708
Purchase Order:	

Michelle Owens, Project Manager
rowens@stl-inc.com

Sample Summary

Order: S243137
Date Received: 05/07/2002
Client: Solutia Inc.
Project: RM842100

Client Sample ID	Lab Sample ID	Matrix	Date Sampled
#5 Location 138’	S243137*1	OIL	05/03/2002 15:00

Analytical Data Report

Lab Sample ID	Description	Matrix	Date Received	Date Sampled	SDG#
43137-1	#5 Location 138’	OIL	05/07/02	05/03/02 15:00	

Parameter	Units	Lab Sample IDs 43137-1
Volatiles by GC/MS (8260)		
Chloromethane	ug/l	<500000
Bromomethane (Methyl bromide)	ug/l	<500000
Vinyl chloride	ug/l	<500000
Chloroethane	ug/l	<500000
Methylene chloride (Dichloromethane)	ug/l	<250000
Acetone	ug/l	<2500000
Carbon disulfide	ug/l	<250000
1,1-Dichloroethene	ug/l	<250000
1,1-Dichloroethane	ug/l	<250000
Cis/Trans-1,2-Dichloroethene	ug/l	<250000
Chloroform	ug/l	<250000
1,2-Dichloroethane	ug/l	<250000
2-Butanone (MEK)	ug/l	<1200000
1,1,1-Trichloroethane	ug/l	<250000
Carbon tetrachloride	ug/l	<250000
Bromodichloromethane	ug/l	<250000
1,1,2,2-Tetrachloroethane	ug/l	<250000
1,2-Dichloropropane	ug/l	<250000
trans-1,3-Dichloropropene	ug/l	<250000
Trichloroethene	ug/l	<250000
Dibromochloromethane	ug/l	<250000
1,1,2-Trichloroethane	ug/l	<250000
Benzene	ug/l	<250000
cis-1,3-Dichloropropene	ug/l	<250000
Bromoform	ug/l	<250000
2-Hexanone	ug/l	<1200000
4-Methyl-2-pentanone (MIBK)	ug/l	<1200000
Tetrachloroethene	ug/l	<250000
Toluene	ug/l	<250000
Chlorobenzene	ug/l	1600000
Ethylbenzene	ug/l	<250000
Styrene	ug/l	<250000
Xylenes, Total	ug/l	<500000
Surrogate - Toluene-d8 *	%	94 %
Surrogate - 4-Bromofluorobenzene *	%	86 %

Analytical Data Report

Lab Sample ID	Description	Matrix	Date Received	Date Sampled	SDG#
43137-1	#5 Location 138’	OIL	05/07/02	05/03/02 15:00	

Parameter	Units	Lab Sample IDs 43137-1
Volatiles by GC/MS (8260)		
Surrogate - Dibromofluoromethane *	%	88 %
Dilution Factor		50000
Analysis Date		05/15/02
Batch ID		1P0515
TCL Semivolatiles (8270)		
Phenol	ug/kg dw	<2600000
bis(2-Chloroethyl)ether	ug/kg dw	<2600000
2-Chlorophenol	ug/kg dw	<2600000
1,3-Dichlorobenzene	ug/kg dw	<2600000
1,4-Dichlorobenzene	ug/kg dw	<2600000
1,2-Dichlorobenzene	ug/kg dw	21000000
2-Methylphenol (o-Cresol)	ug/kg dw	<2600000
2,2’-Oxybis(1-Chloropropane) (bis-2-chloroisopropyl ether	ug/kg dw	<2600000
3-Methylphenol/4-Methylphenol (m&p-Cresol)	ug/kg dw	<2600000
N-Nitroso-di-n-propylamine	ug/kg dw	<2600000
Hexachloroethane	ug/kg dw	<2600000
Nitrobenzene	ug/kg dw	<2600000
Isophorone	ug/kg dw	<2600000
2-Nitrophenol	ug/kg dw	<2600000
2,4-Dimethylphenol	ug/kg dw	<2600000
bis(2-Chloroethoxy)methane	ug/kg dw	<2600000
2,4-Dichlorophenol	ug/kg dw	<2600000
1,2,4-Trichlorobenzene	ug/kg dw	4500000
Naphthalene	ug/kg dw	<2600000
4-Chloroaniline	ug/kg dw	<5200000
Hexachlorobutadiene	ug/kg dw	<2600000
4-Chloro-3-methylphenol	ug/kg dw	<2600000
2-Methylnaphthalene	ug/kg dw	<2600000
Hexachlorocyclopentadiene	ug/kg dw	<2600000
2,4,6-Trichlorophenol	ug/kg dw	<2600000
2,4,5-Trichlorophenol	ug/kg dw	<2600000

Analytical Data Report

Lab Sample ID	Description	Matrix	Date Received	Date Sampled	SDG#
43137-1	#5 Location 138'	OIL	05/07/02	05/03/02 15:00	

Lab Sample IDs

Parameter	Units	43137-1
TCL Semivolatiles (8270)		
2-Chloronaphthalene	ug/kg dw	<2600000
2-Nitroaniline	ug/kg dw	<13000000
Dimethylphthalate	ug/kg dw	<2600000
Acenaphthylene	ug/kg dw	<2600000
3-Nitroaniline	ug/kg dw	<13000000
Acenaphthene	ug/kg dw	<2600000
2,4-Dinitrophenol	ug/kg dw	<13000000
4-Nitrophenol	ug/kg dw	<13000000
Dibenzofuran	ug/kg dw	<2600000
2,4-Dinitrotoluene	ug/kg dw	<2600000
2,6-Dinitrotoluene	ug/kg dw	<2600000
Diethylphthalate	ug/kg dw	<2600000
4-Chlorophenylphenyl ether	ug/kg dw	<2600000
Fluorene	ug/kg dw	<2600000
4-Nitroaniline	ug/kg dw	<13000000
4,6-Dinitro-2-methylphenol	ug/kg dw	<13000000
N-Nitrosodiphenylamine	ug/kg dw	<2600000
4-Bromophenylphenyl ether	ug/kg dw	<2600000
Hexachlorobenzene	ug/kg dw	<2600000
Pentachlorophenol	ug/kg dw	<13000000
Phenanthrene	ug/kg dw	<2600000
Anthracene	ug/kg dw	<2600000
Di-n-butylphthalate	ug/kg dw	<2600000
Fluoranthene	ug/kg dw	<2600000
Pyrene	ug/kg dw	<2600000
Butylbenzylphthalate	ug/kg dw	<2600000
3,3'-Dichlorobenzidine	ug/kg dw	<5200000
Benzo(a)anthracene	ug/kg dw	<2600000
bis(2-Ethylhexyl)phthalate	ug/kg dw	<2600000
Chrysene	ug/kg dw	<2600000
Di-n-octylphthalate	ug/kg dw	<2600000
Benzo(b)fluoranthene	ug/kg dw	<2600000
Benzo(k)fluoranthene	ug/kg dw	<2600000
Benzo(a)pyrene	ug/kg dw	<2600000
Indeno(1,2,3-cd)pyrene	ug/kg dw	<2600000
Dibenzo(a,h)anthracene	ug/kg dw	<2600000

Analytical Data Report

Lab Sample ID	Description	Matrix	Date Received	Date Sampled	SDG#
43137-1	#5 Location 138'	OIL	05/07/02	05/03/02 15:00	

Parameter	Units	Lab Sample IDs 43137-1
TCL Semivolatiles (8270)		
Benzo(g,h,i)perylene	ug/kg dw	<2600000
Carbazole	ug/kg dw	<2600000
Dilution Factor		20
Prep Date		05/09/02
Analysis Date		05/17/02
Batch ID		0509D
TCL Pesticides		
alpha-BHC	mg/kg	<7.8*F65
beta-BHC	mg/kg	<7.8
delta-BHC	mg/kg	<7.8
gamma-BHC (Lindane)	mg/kg	<7.8
Heptachlor	mg/kg	<7.8
Aldrin	mg/kg	<7.8
Heptachlor epoxide	mg/kg	<7.8
Endosulfan I	mg/kg	<7.8
Dieldrin	mg/kg	<15
4,4'-DDE	mg/kg	<15
Endrin	mg/kg	<15
Endrin aldehyde	mg/kg	<15
Endosulfan II	mg/kg	<15
4,4'-DDD	mg/kg	<15
Endosulfan sulfate	mg/kg	<15
4,4'-DDT	mg/kg	23P
Endrin ketone	mg/kg	<15
Methoxychlor	mg/kg	<78
alpha-Chlordane	mg/kg	<7.8
gamma-Chlordane	mg/kg	<7.8
Toxaphene	mg/kg	<780
Surrogate - DCB *	mg/kg	*F33
Surrogate - 2,4,5,6-Tetrachloro-m-xylene (TCMX) *	mg/kg	*F33
Dilution Factor		200
Prep Date		05/13/02
Analysis Date		05/14/02
Batch ID		0513R

Analytical Data Report

Lab Sample ID	Description	Matrix	Date Received	Date Sampled	SDG#
43137-1	#5 Location 138’	OIL	05/07/02	05/03/02 15:00	

Parameter	Units	Lab Sample IDs 43137-1
Chlorinated Herbicides		
2,4-D	mg/kg	<25*F65
2,4-DB	mg/kg	<25
2,4,5-T	mg/kg	<25
2,4,5-TP (Silvex)	mg/kg	<25
Dalapon	mg/kg	<6000
Dicamba	mg/kg	<60
Dichloroprop	mg/kg	<300
Dinoseb	mg/kg	<300
MCPA[(4-chloro-2-methylphenoxy)-acetic acid]	mg/kg	<6000
MCPP[2-(4-chloro-2-methylphenoxy)-propanoic acid]	mg/kg	<6000
Surrogate-DCAA *	mg/kg	*F33
Dilution Factor		100
Prep Date		05/10/02
Analysis Date		05/13/02
Batch ID		0510N
Polychlorinated Biphenyls		
Monochlorobiphenyl	ug/kg	<9900
Dichlorobiphenyl	ug/kg	<9900
Trichlorobiphenyl	ug/kg	17000
Tetrachlorobiphenyl	ug/kg	25000
Pentachlorobiphenyl	ug/kg	<20000
Hexachlorobiphenyl	ug/kg	<20000
Heptachlorobiphenyl	ug/kg	<30000
Octachlorobiphenyl	ug/kg	<30000
Nonachlorobiphenyl	ug/kg	<51000
Decachlorobiphenyl	ug/kg	<51000
Dilution Factor		10
Prep Date		05/09/02
Analysis Date		05/14/02
Batch ID		0509E

Analytical Data Report

Lab Sample ID	Description	Matrix	Date Received	Date Sampled	SDG#
43137-1	#5 Location 138'	OIL	05/07/02	05/03/02 15:00	

		Lab Sample IDs
Parameter	**Units**	**43137-1**
Specific Gravity		
Specific Gravity	g/ml	1.3
Dilution Factor		1
Prep Date		05/16/02
Analysis Date		05/16/02
Batch ID		0516A

Analytical Data Report

Lab Sample ID	Description	Matrix	Date Received	Date Sampled	SDG#
43137-2	Method Blank	QC-0	05/07/02		
43137-3	Lab Control Standard % Recovery	QC-0	05/07/02		
43137-4	LCS Accuracy Control Limit (%R)	QC-0	05/07/02		

Parameter	Units	Lab Sample IDs 43137-2	 43137-3	 43137-4
Volatiles by GC/MS (8260)				
Chloromethane	ug/l	<10		
Bromomethane (Methyl bromide)	ug/l	<10		
Vinyl chloride	ug/l	<10		
Chloroethane	ug/l	<10		
Methylene chloride (Dichloromethane)	ug/l	<5.0		
Acetone	ug/l	<50		
Carbon disulfide	ug/l	<5.0		
1,1-Dichloroethene	ug/l	<5.0	132 %	46-147 %
1,1-Dichloroethane	ug/l	<5.0		
Cis/Trans-1,2-Dichloroethene	ug/l	<5.0		
Chloroform	ug/l	<5.0		
1,2-Dichloroethane	ug/l	<5.0		
2-Butanone (MEK)	ug/l	<25		
1,1,1-Trichloroethane	ug/l	<5.0		
Carbon tetrachloride	ug/l	<5.0		
Bromodichloromethane	ug/l	<5.0		
1,1,2,2-Tetrachloroethane	ug/l	<5.0		
1,2-Dichloropropane	ug/l	<5.0		
trans-1,3-Dichloropropene	ug/l	<5.0		
Trichloroethene	ug/l	<5.0	124 %	56-143 %
Dibromochloromethane	ug/l	<5.0		
1,1,2-Trichloroethane	ug/l	<5.0		
Benzene	ug/l	<5.0	132 %	62-135 %
cis-1,3-Dichloropropene	ug/l	<5.0		
Bromoform	ug/l	<5.0		
2-Hexanone	ug/l	<25		
4-Methyl-2-pentanone (MIBK)	ug/l	<25		
Tetrachloroethene	ug/l	<5.0		
Toluene	ug/l	<5.0	124 %	68-131 %
Chlorobenzene	ug/l	<5.0	122 %	72-127 %
Ethylbenzene	ug/l	<5.0		
Styrene	ug/l	<5.0		
Xylenes, Total	ug/l	<10		

Analytical Data Report

Lab Sample ID	Description	Matrix	Date Received	Date Sampled	SDG#
43137-2	Method Blank	QC-O	05/07/02		
43137-3	Lab Control Standard % Recovery	QC-O	05/07/02		
43137-4	LCS Accuracy Control Limit (%R)	QC-O	05/07/02		

		Lab Sample IDs		
Parameter	**Units**	**43137-2**	**43137-3**	**43137-4**
Volatiles by GC/MS (8260)				
Surrogate - Toluene-d8 *	%	94 %	88 %	77-122 %
Surrogate - 4-Bromofluorobenzene *	%	88 %	84 %	74-126 %
Surrogate - Dibromofluoromethane *	%	94 %	84 %	70-130 %
Dilution Factor		1	1	
Analysis Date		05/15/02	05/15/02	
Batch ID		1P0515	1P0515	
TCL Semivolatiles (8270)				
Phenol	ug/kg dw	<99000	*	*
bis(2-Chloroethyl)ether	ug/kg dw	<99000		
2-Chlorophenol	ug/kg dw	<99000		
1,3-Dichlorobenzene	ug/kg dw	<99000		
1,4-Dichlorobenzene	ug/kg dw	<99000		
1,2-Dichlorobenzene	ug/kg dw	<99000		
2-Methylphenol (o-Cresol)	ug/kg dw	<99000		
2,2'-Oxybis(1-Chloropropane) (bis-2-chloroisopropyl ether	ug/kg dw	<99000		
3-Methylphenol/4-Methylphenol (m&p-Cresol)	ug/kg dw	<99000		
N-Nitroso-di-n-propylamine	ug/kg dw	<99000		
Hexachloroethane	ug/kg dw	<99000		
Nitrobenzene	ug/kg dw	<99000		
Isophorone	ug/kg dw	<99000		
2-Nitrophenol	ug/kg dw	<99000		
2,4-Dimethylphenol	ug/kg dw	<99000		
bis(2-Chloroethoxy)methane	ug/kg dw	<99000		
2,4-Dichlorophenol	ug/kg dw	<99000		
1,2,4-Trichlorobenzene	ug/kg dw	<99000		
Naphthalene	ug/kg dw	<99000		
4-Chloroaniline	ug/kg dw	<200000		
Hexachlorobutadiene	ug/kg dw	<99000		

Analytical Data Report

Lab Sample ID	Description	Matrix	Date Received	Date Sampled	SDG#
43137-2	Method Blank	QC-O	05/07/02		
43137-3	Lab Control Standard % Recovery	QC-O	05/07/02		
43137-4	LCS Accuracy Control Limit (%R)	QC-O	05/07/02		

Parameter	Units	Lab Sample IDs 43137-2	43137-3	43137-4
TCL Semivolatiles (8270)				
4-Chloro-3-methylphenol	ug/kg dw	<99000		
2-Methylnaphthalene	ug/kg dw	<99000		
Hexachlorocyclopentadiene	ug/kg dw	<99000		
2,4,6-Trichlorophenol	ug/kg dw	<99000		
2,4,5-Trichlorophenol	ug/kg dw	<99000		
2-Chloronaphthalene	ug/kg dw	<99000		
2-Nitroaniline	ug/kg dw	<510000		
Dimethylphthalate	ug/kg dw	<99000		
Acenaphthylene	ug/kg dw	<99000		
3-Nitroaniline	ug/kg dw	<510000		
Acenaphthene	ug/kg dw	<99000		
2,4-Dinitrophenol	ug/kg dw	<510000		
4-Nitrophenol	ug/kg dw	<510000		
Dibenzofuran	ug/kg dw	<99000		
2,4-Dinitrotoluene	ug/kg dw	<99000		
2,6-Dinitrotoluene	ug/kg dw	<99000		
Diethylphthalate	ug/kg dw	<99000		
4-Chlorophenylphenyl ether	ug/kg dw	<99000		
Fluorene	ug/kg dw	<99000		
4-Nitroaniline	ug/kg dw	<510000		
4,6-Dinitro-2-methylphenol	ug/kg dw	<510000		
N-Nitrosodiphenylamine	ug/kg dw	<99000		
4-Bromophenylphenyl ether	ug/kg dw	<99000		
Hexachlorobenzene	ug/kg dw	<99000		
Pentachlorophenol	ug/kg dw	<510000		
Phenanthrene	ug/kg dw	<99000		
Anthracene	ug/kg dw	<99000		
Di-n-butylphthalate	ug/kg dw	<99000		
Fluoranthene	ug/kg dw	<99000		
Pyrene	ug/kg dw	<99000		
Butylbenzylphthalate	ug/kg dw	<99000		
3,3'-Dichlorobenzidine	ug/kg dw	<200000		
Benzo(a)anthracene	ug/kg dw	<99000		
bis(2-Ethylhexyl)phthalate	ug/kg dw	<99000		

Analytical Data Report

Lab Sample ID	Description	Matrix	Date Received	Date Sampled	SDG#
43137-2	Method Blank	QC-0	05/07/02		
43137-3	Lab Control Standard % Recovery	QC-0	05/07/02		
43137-4	LCS Accuracy Control Limit (%R)	QC-0	05/07/02		

		Lab Sample IDs		
Parameter	**Units**	**43137-2**	**43137-3**	**43137-4**
TCL Semivolatiles (8270)				
Chrysene	ug/kg dw	<99000		
Di-n-octylphthalate	ug/kg dw	<99000		
Benzo(b)fluoranthene	ug/kg dw	<99000		
Benzo(k)fluoranthene	ug/kg dw	<99000		
Benzo(a)pyrene	ug/kg dw	<99000		
Indeno(1,2,3-cd)pyrene	ug/kg dw	<99000		
Dibenzo(a,h)anthracene	ug/kg dw	<99000		
Benzo(g,h,i)perylene	ug/kg dw	<99000		
Carbazole	ug/kg dw	<99000		
Dilution Factor		1		
Prep Date		05/09/02		
Analysis Date		05/16/02		
Batch ID		0509D		
TCL Pesticides				
alpha-BHC	mg/kg	<0.050	*	*
beta-BHC	mg/kg	<0.050		
delta-BHC	mg/kg	<0.050		
gamma-BHC (Lindane)	mg/kg	<0.050		
Heptachlor	mg/kg	<0.050		
Aldrin	mg/kg	<0.050		
Heptachlor epoxide	mg/kg	<0.050		
Endosulfan I	mg/kg	<0.050		
Dieldrin	mg/kg	<0.10		
4,4'-DDE	mg/kg	<0.10		
Endrin	mg/kg	<0.10		
Endrin aldehyde	mg/kg	<0.10		
Endosulfan II	mg/kg	<0.10		
4,4'-DDD	mg/kg	<0.10		
Endosulfan sulfate	mg/kg	<0.10		
4,4'-DDT	mg/kg	<0.10		
Endrin ketone	mg/kg	<0.10		
Methoxychlor	mg/kg	<0.50		

Analytical Data Report

Lab Sample ID	Description	Matrix	Date Received	Date Sampled	SDG#
43137-2	Method Blank	QC-O	05/07/02		
43137-3	Lab Control Standard % Recovery	QC-O	05/07/02		
43137-4	LCS Accuracy Control Limit (%R)	QC-O	05/07/02		

Parameter	Units	Lab Sample IDs 43137-2	43137-3	43137-4
TCL Pesticides				
alpha-Chlordane	mg/kg	<0.050		
gamma-Chlordane	mg/kg	<0.050		
Toxaphene	mg/kg	<5.0		
Surrogate - DCB *	mg/kg	*F33		
Surrogate - 2,4,5,6-Tetrachloro-m-xylene (TCMX) *	mg/kg	*F33		
Dilution Factor		1		
Prep Date		05/13/02		
Analysis Date		05/14/02		
Batch ID		0513R		
Chlorinated Herbicides				
2,4-D	mg/kg	<0.25	105 %	19-153 %
2,4-DB	mg/kg	<0.25	110 %	20-160 %
2,4,5-T	mg/kg	<0.25	110 %	14-143 %
2,4,5-TP (Silvex)	mg/kg	<0.25	110 %	27-120 %
Dalapon	mg/kg	<60	90 %	10-170 %
Dicamba	mg/kg	<0.60	125 %	20-160 %
Dichloroprop	mg/kg	<3.0	75 %	30-170 %
Dinoseb	mg/kg	<3.0	75 %	0-130 %
MCPA[(4-chloro-2-methylphenoxy)-acetic acid]	mg/kg	<60	105 %	10-130 %
MCPP[2-(4-chloro-2-methylphenoxy)-propanoic acid]	mg/kg	<60	120 %	10-130 %
Surrogate-DCAA *	%	105 %	105 %	30-189 %
Dilution Factor		1	1	
Prep Date		05/10/02	05/10/02	
Analysis Date		05/13/02	05/13/02	
Batch ID		0510N	0510N	

Analytical Data Report

Lab Sample ID	Description	Matrix	Date Received	Date Sampled	SDG#
43137-2	Method Blank	QC-O	05/07/02		
43137-3	Lab Control Standard % Recovery	QC-O	05/07/02		
43137-4	LCS Accuracy Control Limit (%R)	QC-O	05/07/02		

		Lab Sample IDs		
Parameter	**Units**	**43137-2**	**43137-3**	**43137-4**
Polychlorinated Biphenyls				
Monochlorobiphenyl	ug/kg	<990	*	*
Dichlorobiphenyl	ug/kg	<990		
Trichlorobiphenyl	ug/kg	<990		
Tetrachlorobiphenyl	ug/kg	<2000		
Pentachlorobiphenyl	ug/kg	<2000		
Hexachlorobiphenyl	ug/kg	<2000		
Heptachlorobiphenyl	ug/kg	<3000		
Octachlorobiphenyl	ug/kg	<3000		
Nonachlorobiphenyl	ug/kg	<5100		
Decachlorobiphenyl	ug/kg	<5100		
Dilution Factor		1		
Prep Date		05/09/02		
Analysis Date		05/14/02		
Batch ID		0509E		
Specific Gravity				
Specific Gravity		---	---	---

These test results meet all the requirements of NELAC. All questions regarding this test report should be directed to the STL Project Manager who signed this test report.
*F33 = Control limits are established only for surrogate concentration levels specified by EPA methods. Because the sample was diluted prior to analysis, surrogate recoveries are not reported.

*F65 = Elevated detection limits were reported due to sample matrix interference which required sample or extract dilution.